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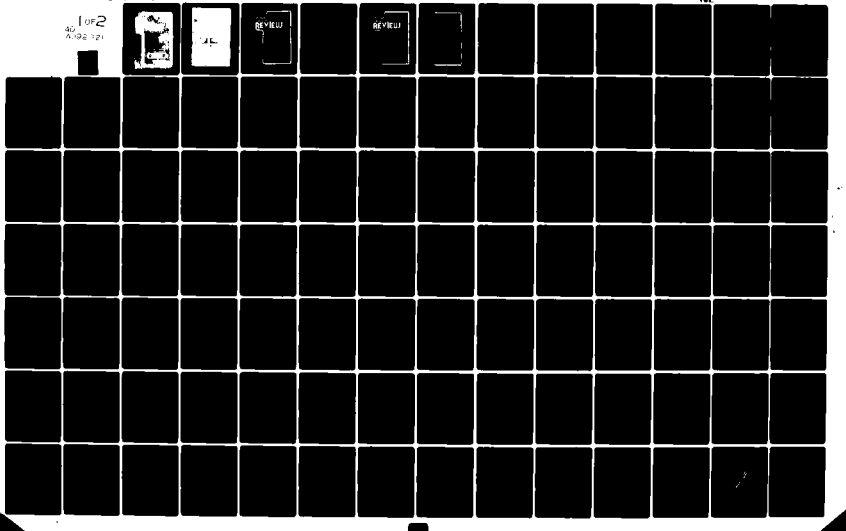

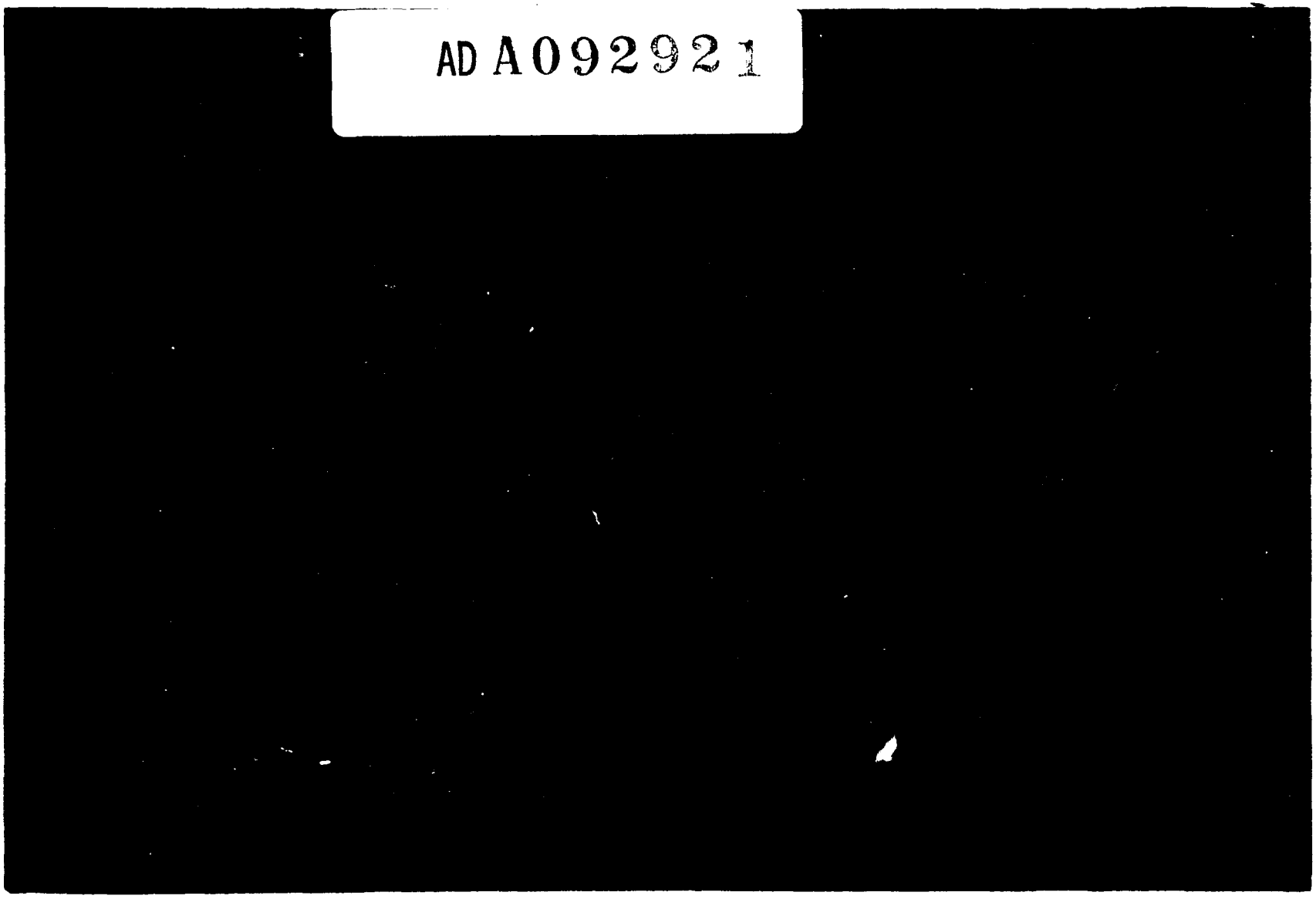

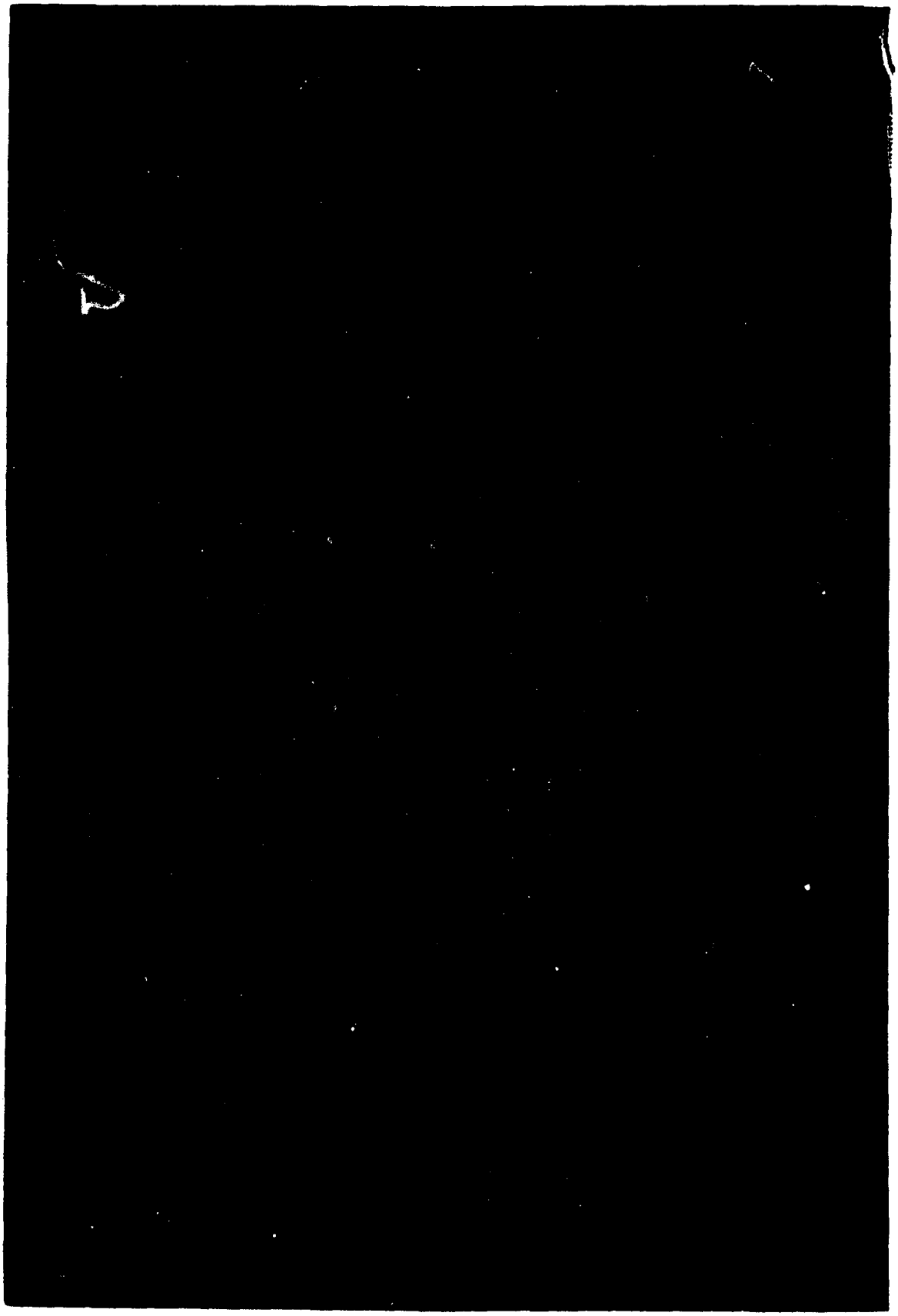

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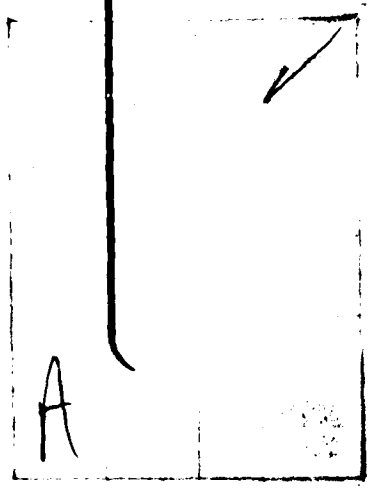

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DEFENSE SYSTEMS MANAGEMENT REVIEW

Defense Acquisition: Issues and Answers

from the editor...

Once again, we remind you that we will be using our old mailing list until the new mailing system is operational, meaning that any address change you sent us during our recent mailing list update is being held for the new system. If you have not sent us your correct mailing address, do it now. We must have your mailing address (even if the address we have for you now is correct) or you will be dropped from our list, no matter how long you have been receiving material from the College.

At the same time we convert to the new system we will consolidate the mailing lists for the Defense Systems Management Review *and the bimonthly College newsletter,* Program Manager. *This means that those of you who now receive only the* Review *will begin to receive* Program Manager *also. Those of you who already receive both publications will be unaffected.*

We are looking now at possible "themes" for future issues of the Review. *The idea is to feature a particular acquisition problem or issue by having several articles devoted to it in a single edition of the* Review. *If you have an idea for a topic you would like to see examined in these pages, let us know.*

7 Affordability and the Acquisition of Major Defense Systems

Dr. F. C. E. Oder

There has been a history of cost growth in U.S. weapon system acquisition and support which has had a continuing impact on the numbers and types of systems we can acquire.

As early as 1971, DOD Directive 5000.1, "Acquisition of Major Defense Systems," recognized that system cost should be a factor in trade-off decisions. In 1973, "design-to-cost" became an element of importance prior to entering full-scale development (FSD) and, subsequently, life-cycle costs (LCC) became recognized as perhaps the predominant feature of total systems cost. In 1977, DOD Directive 5000.2, "Major System Acquisition Process," delineated affordability objectives and specified that acquisition and ownership costs are to be separate cost elements prior to the FSD phase. Cost growth of these elements was considered by the Defense Science Board Summer Study in 1977, which reinforced the concept of "affordability."

Finally, the recent draft of DOD Directive 5000.1, "Major System Acquisitions," would have the affordability of a major system to be determined at each milestone decision point. Some elements of affordability would be the projected share of the defense budget for the system's mission area and the projected LCC of the system. Thus, it is clear that within the past decade, the realization of escalating costs in major systems acquisition requires that total system costs become a determinate factor in the choice of future systems needed to assure the nation's security.

At this point a very key, often unanswered, question arises. How much *should* we pay to counter the threat? We don't have a precise answer, but we know it could be costly, even more so when we consider operation and support costs. Closer to the point, "Can we *afford* it?" Even more important, can we continue to afford it in the out-years?

The Elements of Affordability

In order to provide some perspective on the concept of affordability, I will examine its components as viewed from industry.

Webster defines "afford" as — "to be able to bear the cost of." Thus, we see the predominant factors of affordability to be *cost* and *budget availability*. The cost component encompasses acquisition and ownership elements whereas budget availability means that the funds are there when the bills come in. Let me

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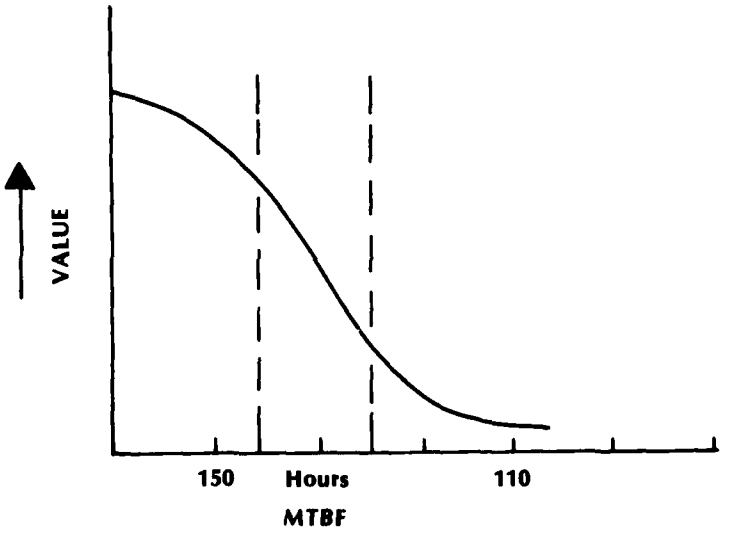
emphasize that funding has to be available through the life cycle of the program if the true meaning of "affordability" is to be followed, and it is not to become another ephemeral buzzword.

I am sure it is clear that when we consider acquisition costs, we must look beyond the development program costs because there are many other costs that must be accounted for. Time does not permit a litany of every cost element; however, I will highlight some of the more important facets.

Design-to-cost—important? Yes. We must continue to recognize that there are certain bounds to the value of a particular item. Here the broad judgment of DOD should have a strong influence. Costs can be driven up by the misguided concept of invoking military specifications for every component. Costs will also burgeon if the last few percent of system performance is demanded (i.e., "goldplating"). This is vividly portrayed by Dr. Don Hurta of the Defense Systems Management College in a risk analysis discussion as indicated in Figure 1.

While we desire 150 hours mean time betweeen failure (MTBF), where does the goldplating begin? Can we accept 125 hours, or do we demand 135 hours?

FIGURE 1
Risk Analysis



How much will it cost to go from 125 hours to 135 hours? Conversely, will there be savings in field support costs? This is a simplified example, but illustrates the need to establish an optimum design-to-cost parameter, and not to succumb to the credo of "higher performance by itself gives a better system."

Another cost element is the degree of optimization of the development span. "Early deployment also permits a shortened acquisition time for the initial operational capability, which also has considerable value in terms of dollars spent."[1]

The other side of the coin is labeled "ownership costs." Our primary concern here is operation and support costs which are major elements and which are usually overlooked. Life-cycle cost elements such as initial spares and replenishment spares, support equipment, depot facilities and depot maintenance functions, software support, technical data, training and maintaining military and Civil Service personnel required to develop, test and operate the system, hidden overhead costs, and others must be tabulated. Today, with the increased sophistication in modern weapon systems, affordability must even be concerned with field maintenance procedures. In order to achieve a high rate of operability, it will be imperative to design to module replacement, considering the level of technical competence of the user personnel.

Thus, it is clearly evident that "affordability" considerations must come into being at the conceptual phase of the program, and must encompass not only the development agency, but also user, support, and planning agencies to have a meaningful impact on total costs.

At Milestone II, a tentative decision is made to enter production and thus deploy the system. Having prioritized the various systems because of budget constraints, it is increasingly important to stress out-year planning and to ensure that appropriate budget levels are available for production, operation and support. A technical risk threshold would be established also, and management reserve funds would be identified for possible back-up programs.

How closely involved should industry be during the various phases? To ensure cost-effectiveness, industry should be included in pre-Milestone 0 efforts, and specifically should be given guidance on cost bounds as a result of the Milestone 0 decision.

Importance of Affordability

A high degree of understanding by industry is necessary if the concept of affordability is to succeed. As we understand the concept, it will prioritize programs for a specific mission area in a more rigorous fashion, deleting marginal

1. Defense Science Board 1977 Summer Study, "Report of the Acquisition Cycle Task Force," March 15, 1978.

programs at an early phase, thereby assuring budget availability for production, deployment, and support of the systems we can afford. In this sense, affordability is an insurance policy for those systems that are planned for deployment.

There is an important by-product in that a stabilizing influence should be experienced in defense-related industries. This could impact the cost structure in a favorable way. Thus, economics of affordability would be expressed in work-force stability, precluding violent cyclical aberrations in hiring/firing phases, so typical over the years. Work-force stability engenders a "team" spirit, allows for greater maturity in engineering design because of experience and "lessons learned," and encourages innovative approaches in the search for solutions to current and future problems.

Stability would also be exhibited in the planning process, both in the military and industrial arenas. Planning and scheduling activities could be anchored on a more rational base, a very important consideration. This will have a two-fold effect. It will allow a more prudent and in-depth look at system elements that conceivably could pose technical risks. Thus, if the system is a *must-go*, planning could include back-up programs in the event specific solutions are not achieved. The other aspect to planning stability concerns costs. It goes without saying that a well-planned program which considered all the sub-elements will be more cost effective than one which generates "surprises" as it proceeds. It is also clear that an essential feature of the true concept of affordability is the requirement for precise programmatic decisions that are not subject to severe, short-term oscillations, so characteristic today.

An affordability limitation on the number of major weapon systems that are planned for development and deployment is important and provides advantages to both government and industry. With fewer systems being proposed, the government will be ensured of receiving better and more highly competitive proposals from industry, with more emphasis being put on cost, reliability, maintainability, and support. Industry, on the other hand, understanding the true intent of the DOD in fielding systems, can feel more secure in concentrating resources and energy in systems most likely to emerge, and therefore can allow room for more concerted efforts for innovative solutions.

From a broad point of view, the affordability concept will provide important program competition within DOD, ensuring that only the fittest and best will survive. The affordability crunch caused by tight budgets, escalating costs, and clogged R&D pipelines will then be somewhat alleviated.

The impact of affordability on the national technological base deserves some attention as this base is critical to any weapon system development. Careful budgeting for development, production and support on a limited number of weapons programs could make available additional funding for vital technology

areas which, if properly structured, could be complementary to advanced and full-scale development programs. More reliance should be put on industry to ascertain the state-of-the-art in assisting the DOD to determine what can, and cannot, be achieved. This is particularly highlighted in the electronics field where quantum advances are made on a regular basis.

While there is much experience in cost estimation for development and test programs, more effort should be put into acquiring a meaningful data base on life cycle and operating support costs. The importance of such a data base cannot be ignored. It is these areas that are major contributors to cost escalation since little attention has been devoted to them in the past.

Quantification

Is it possible to accurately determine a system's cost during the conceptual phase within the context of the affordability concept? The answer is clearly "no." It is impossible to establish costs when we have only a requirement to be satisfied, no specific hardware design, and many candidate alternative solutions.

Operations research techniques, however, could be important tools in arriving at "cost bounds" for Milestone 0. Among the many considerations to be traded off are the importance of the threat, its value, and also the "consequences" of killing the threat. Is there a "domino effect?" If so, it would appear to be of high importance, and we might like to put more resources into a system to defeat the threat. If there is no such effect, we might be inclined to constrain the resources. But above all, we should not make decisions based solely on the output of the gaming. It is essential that military judgments be exercised, with important input from the users.

Starting with the "bounds" at Milestone 0, continuing military/industry dialogue and meaningful trade studies should result in confident cost numbers at Milestone II.

MENS Approval

Finally, we can't discuss affordability without consideration of the mission element need statement (MENS) and its impact on the acquisition cycle. This new acquisition philosophy would require, as part of the MENS package, an affordability constraint identifying the estimated magnitude of the acquisition, and operation and support costs of the system to satisfy the need. We assume the DOD component advocate would be responsible for the cost estimates and for continuously updating them as we approach Milestone II.

Even though the MENS is approved, it is important for industry to understand that it only affirms that there is a need to correct a deficiency in a narrowly defined mission area. It does not confirm a program commitment. In fact, the

particular alternatives being considered to satisfy the need may not make it past Milestone I. Therein lies the important connection between MENS and affordability, which will weed out marginal programs.

Summary

We have seen a continuing cost growth in weapon systems acquisition and support over the years. The proper implementation of A-109, coupled with recommendations of the Defense Science Board Study, "Report of the Acquisition Cycle Task Force," concerning acquisition policy, should enable a more rational judgment on total weapon systems costs and enable deployment of those systems that are affordable.

The concept of affordability, its management and impact on major programs are, I believe, appreciated to some extent within the services. In a recent address to a group of industry executives at Headquarters, Air Force Contract Management Division, Kirtland AFB, New Mexico. General Alton Slay, Commander, Air Force Systems Command, addressed the importance of affordability to the Air Force and to industry. He noted the operation of Project VANGUARD under Major General John Toomay directed toward the prioritzation of all significant Air Force programs.

A total DOD-wide integrated, funded, and agreed-to affordability management plan, which Congress would recognize and therefore commit not only near-term funding, but also out-year funding for all program components, is certainly a hoped-for, but hard-to-believe, expectation. Let me note, however, that a continuation of the current program "bow wave" in excess of anticipated funding is not too attractive to either the government or industry.

A significant one-time negative effect on industry might be expected when affordability matures. Look beyond that event and consider the practical value of a more stable and less chaotic environment. It is not hard to predict significant improvements in true productivity and, most importantly, better defense capability.

It is seen that operations research techniques can play an important part in arriving at "cost bounds" for Milestone 0. We should temper the results, however, with sound military judgments including important inputs from the users.

The new acquisition philosophy requiring MENS approval for selected systems will assist in supporting the affordability concept because total systems cost will be bounded at Milestone 0. Industry must understand that this approval only affirms a need, and not a program commitment.

Many attempts have been made to improve the acquisition process of weapons systems over the past decades. For a variety of reasons, the majority of

these initiatives for improvements have not succeeded, hence we have not had adequate budget available for production and deployment in a number of cases.

The affordability concept, when applied appropriately and with determination in all phases of the acquisition process, will be a positive element for both the government, industry, and the taxpayer to ensure that we will be able to deploy adequate systems in support of national security.

Concurrency Today in Acquisition Management

14

Thomas E. Harvey

The materiel acquisition challenge faced by the Department of Defense today—to provide needed systems to our fighting forces in a time of diminishing resources—is not new. No doubt any program manager who has ever managed a program has felt that, if only he could budget some 20 percent more than was available, most of his problems would be solved.

Not new either, are discussions of how to solve this challenge, or the reactions to some of the solutions which have been attempted.

What may be new today is the unprecedented number of highly sophisticated systems completing research and development and ready for procurement. Along with the unprecedented sophistication of these systems comes their unprecedented cost.[1] This has given rise to the considerable attention focused on the "bow wave" phenomenon discussed throughout the Pentagon as the services proceed through the congressional budget cycle. The bow wave describes a program/budget phenomenon caused by moving a significant number of unfunded program elements into future years in hopes that when those years arrive, priorities will be such as to permit them to be funded. In essence, the bow wave describes the need for funds in the budget within the immediate future far beyond what can reasonably be anticipated.

One might say that the bow wave has hit the shore. The bow wave phenomenon has focused the attention of managers throughout DOD on the question of how could we—how should we—have managed better to assure the expeditious development and acquisition of needed systems at affordable costs.

This question has been one of particular significance to Dr. William J. Perry, Under Secretary of Defense, Research and Engineering. In 1977, Dr. Perry commissioned a Defense Science Board Task Force on the Acquisition Cycle to consider the problem and recommend ways materiel acquisition could be better managed to assure the early fielding of needed equipment at prices we can afford.

This Task Force, made up principally of industry representatives under the Chairmanship of Dr. Richard D. DeLauer of TRW, Inc., submitted its excellent report in March, 1978.[2] The report examined how we are acquiring various systems today and compared this with how comparable systems have been acquired in times past. It concluded that, invariably, our systems acquisition cycle

1. Within the Army alone, a few of the major systems ready for production, with the amounts requested in the procurement budget for FY 1980 for each are: XM-1 Tank, $650 million; Fighting Vehicle System, $170 million; PATRIOT Air Defense System, $426 million; ROLAND Air Defense System, $283 million; BLACK HAWK Helicopter, $339 million; Advanced Attack Helicopter (FY 81), $301 million.

2. Report of the Acquisition Cycle Task Force, Defense Science Board Summer Study, March 15, 1978.

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has lengthened significantly, even to the point where we risk changes in the threat, the players, and the very concepts of warfare prior to fielding new systems. When this happens, the services are left with a cancelled program that has been essentially a waste, and with equipment in the field that is two generations out of date.

What has caused the acquisition cycle to lengthen as it has? Among other things, the acquisition process is subject to a calcified management system that has grown through layering—like coral. Many of the management systems we have tried in the past have been reactions to particular, usually spectacular, system acquisition failures. As attention has been focused on a particular failure by the media and by Congress, we have attempted to show that we were, if not perfect managers, at least responsive ones. And with that we would institute, and overlay on the existing structure, a new management system with the promise that it would prevent that particular failure from ever occurring again. The Defense Science Board Task Force makes the point that, in time, a series of such often overlapping management systems has become institutionalized.[3] Review and approval, often accomplished in inconsistent milieu—the program process rather than the DSARC/system acquisition process—create more decision points, require more analysis, more justification, more test and evaluation. As a result, the program is delayed by the decision process itself.[4]

How can we do better? Much of the Defense Science Board study is focused on the early and late phases of the systems acquisition process: the definition of a mission need and the problems attendant to moving into full-scale production and deployment of a system that has been demonstrated to be responsive to an acknowledged threat. The study addresses concurrency as one means to accelerate the intermediate steps in the acquisition cycle and recommends that flexibility be instilled into our systems acquisition policy.[5]

This recommendation was seconded by Congressman Richard Ichord, Chairman of the Subcommittee on Research and Development of the House Appropriations Committee in a speech he delivered November 14, 1978, entitled "Technology to Acquisition: The Barrier to Modernization."[6]

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3. *Ibid.*, p. 1.
4. *Ibid.*, p. 35.
5. Department of Defense Directive Number 5000.1 dated January 18, 1977, Subject: Major Systems Acquisition, Implementing OMB Circular A-109, "Major System Acquisition," April 5, 1976. At Section IV.O, DODD 5000.1 acknowledges the need for trade-offs in acquisition planning, but admonishes "task accomplishment without unnecessary concurrency." DODD 5000.1 has been under revision for more than a year. In the working Draft of April 18, 1979, at Section D.2.d, the need for flexibility to speed up the acquisition cycle is noted. To accomplish this, "[c]ommensurate with risk, such techniques as concurrency. . . should be considered." It remains to be seen whether this more positive approach to concurrency will remain in the final version.
6. Richard H. Ichord, "Technology to Acquisition: The Barrier to Modernization," keynote address to the 1978 Government Microcircuit Applications Conference, Monterey, California, November 15, 1978.

In his talk, Mr. Ichord specifically faults a fly-before-buy and lock-step, heel-to-toe, development/operational test approach as being responsible for a significant portion of the observed extension of the acquisition cycle. To shorten that cycle, he recommends accepting the risks in concurrency: relying on testing which is adequate, not redundant; introducing operational testing early in the cycle—where possible, concurrent with development testing. The fly-before-buy approach has application only in instances of high risk, highly sophisticated, complex systems.

In his 1979 statement to Congress on the Department of Defense program for research, development, and acquisition,[7] Dr. Perry again emphasized flexibility in the acquisition cycle. In that statement he focuses on concurrency as an area where significant achievements can be gained through flexibility. He recommends taking a lesson from the highly successful Soviet military acquisition process, which emphasizes meeting deployment schedules, even at the cost of fielding a system whose performance goals cannot initially be realized, then modifying and improving that system, incorporating into it subsystem improvements made possible by later developments.[8]

This approach is a far cry from that mandated by Deputy Secretary of Defense David Packard in 1970 when he directed that all defense systems be developed on a sequential schedule, no movement to a successive phase of development taking place until any problems which may have arisen in a previous phase had been fully resolved.[9] In Secretary Packard's own words: "The ideal schedule is sequential with enough slack time for resolution of those problems which invariably arise in any development program." Even the development of an integrated logistical support program was to be delayed until the establishment of a final production design. This was the ultimate in the heel-to-toe approach to development.

Mr. Packard articulated his rationale for the nonconcurrent approach in an article published in the *Defense Industry Bulletin* in 1971. In that article he said:

> As I reviewed program after program beginning in the spring of 1969, almost all were in trouble from a common fault—production had been started before engineering development was finished. . . Several important policies and procedures have been established to help avoid the disastrous results of concurrency. . . .[10]

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7. William J. Perry, "The FY 1980 Department of Defense Program for Research, Development and Acquisition," Statement to the Congress of the United States, 96th Congress, First Session. Released February 21, 1979.

8. *Ibid.* p. 11-5.

9. Deputy Secretary of Defense Memorandum dated May 28, 1970, Subject: Policy Guidance on Major Weapon System Acquisition, referenced and quoted at length in Defense Science Board Report, p. 48.

10. David Packard, "Defense Industry Must Do a Better Job," *Defense Industry Bulletin*, Fall 1971, p. 4.

The following year, in 1972, the Report of the Commission on Government Procurement cautioned against too much concurrency:

> Committing to extensive production when much development, test, evaluation and redesign still remain to be done usually leads to major retrofit and modification costs. Components, equipment, and tools can be made obsolete by design changes as the development progresses.[11]

The final report of the Defense Resource Management Study,[12] under the direction of Donald B. Rice, President of The Rand Corporation, adopts a view of concurrency consistent with that espoused by Rand for several years.[13] In general, the report finds that program schedule compression through overlap of testing and production almost invariably results in a long and costly modification phase being needed "because there was insufficient opportunity to detect technical and operational defects, correct them, and incorporate changes before substantial numbers of production articles were delivered."[14]

As recently as April 12, 1979, the General Accounting Office wrote to the Secretary of Defense criticizing the XM-1 tank program, in particular the concurrency in it, and recommending that he defer or slow down XM-1 production until acceptable reliability and durability levels are demonstrated.[15] That letter has received considerable media coverage, as have the various problems encountered in the development test and operational test phases of the program to date.

In its letter, the GAO expressed the opinion that:

> It would be preferable to defer the initial production decision [on the XM-1 tank] until there has been a demonstration through further testing that design changes and modifications have indeed corrected the problems. [The GAO] view has been, and continues to be, that total costs are minimized and system performance maximized by a step-by-step approach that recognizes and attempts to resolve high risk technical problems before going into production.

Yet, in today's world of raw material shortages, 2-year or more lead times to get certain types of machine tools, castings, and forgings, eliminating concurrency would be wholly unworkable. To follow a completely sequential acquisition program for as complex a system as the XM-1 tank or the MX missile would

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11. Report of the Commission on Government Procurement, December 31, 1972, Volume 2, p. 146.

12. Donald B. Rice, *Final Report, Defense Resource Management Study*, A Report Requested by the President and Submitted to the Secretary of Defense, February 1979.

13. See R. L. Perry, *et al.*, *Systems Acquisition Strategies*, The Rand Corporation, R-733-PR/ARPA, June 1971.

14. Rice, p. 29.

15. J. H. Stolarow, Director, Procurement and Systems Acquisition Division, United States General Accounting Office, Letter to The Honorable Harold Brown, Secretary of Defense, dated April 12, 1979. GAO Reference Number B-163058.

delay the fielding of those systems well beyond the time they could make a meaningful contribution to the United States defense arsenal.

In its production planning for the XM-1 program, the Army has accepted the risks inherent in concurrency and focused on its benefits as enumerated in the Defense Science Board Study:

—Concurrency provides a smooth transition from development to production;
—Concurrency minimizes the acquisition time span; and
—Concurrency drives the total system to be ready on time.
—In sum, concurrency, when properly done, reduces program costs. ‖

19 Will Four-Step Solve the Problem?

Dr. David N. Burt

The Department of Defense source selection process of negotiated acquisitions has been plagued for years by charges of unfair competition and unsound business practices. Beginning with the Harvard weapons acquisition project in 1962, continuing with various industry studies in the 1960s, through the findings of the Commission on Government Procurement released in the early 1970s, DOD weapon systems acquisition procedures have come under close scrutiny and increased criticism. Past statutes have failed to control, and have even encouraged, such practices as "technical leveling," "technical transfusions," "auctioning," and "buy-ins." Poorly written requests for proposal (RFPs) have added to the confusion and uncertainty surrounding the source-selection process.

In 1976, DOD began a 2-year test study of a source selection method called "four-step" which had been adapted from NASA procedures. The four steps in the process are (1) submission and evaluation of technical proposals; (2) submission and evaluation of cost proposals as well as revisions to technical proposals; (3) the establishment of a common cut-off date for "best-and-final" offers and selection of the apparent winning contractor; and (4) negotiation and award of a definitive contract.

Methodology

A survey using a structured interview was made of 20 San Francisco Bay Area government contractors to gather current industry views on U.S. DOD source selection procedures and problems. A wide range of experiences was sought so that answers would not give the appearance of artificial consensus. Small ($5 million-$15 million annual government sales), medium ($15 million-$50 million) and large (those appearing on the list of the "Top 100 Defense Department Contractors for 1977") contractors participated. Not all of these were actually involved in major weapon systems acquisitions as strictly defined by the DOD dollar threshold. Most of those sampled, however, were primarily involved in negotiated procurements (90 percent-100 percent of their government contracts were negotiated), with many in the $10 million+ category. Preliminary interviews were done by telephone. Those were followed up by questionnaires mailed to the participants, and then by in-person interviews at the contractors' plants.

Author's Note: The research underlying this paper is the basis of a master's thesis by Lieutenant Commander Michael James Miller, SC, USN, entitled "Weapon Systems Source Selection: Is Four-Step the Answer?" This research was conducted under the guidance of the author. LCDR Miller currently is assigned duty overseas. He has given consent to the use of his thesis as the basis of this paper.

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Source Selection Problems

Statement of Work: DOD has been criticized repeatedly for failure to consult with industry in formulating the statement of work. Two of the National Security Industrial Association's recommendations in 1970 were that:

—The Department of Defense and industry should consult to the maximum extent possible during the formulation of weapon system concepts and requirements and prior to contractural solicitation, in order to bring greater realism to assessment of state-of-the-art, schedules, costs, and risks.[1]

—The Department of Defense and industry should review together work statements and specifications prior to soliciting bids for development and production of hardware, so that the technical characteristics and performance criteria defined in requests for proposal on major defense procurements are attainable.[2]

In 1973 National Security Industrial Asociation (NSIA) repeated that DOD-contractor dialogue during the requirements phase gives the customer ". . . a better basis for determining what is achievable and what is merely contractor boasting, the latter motivated more by the competitive environment than confidence that the technical objectives can be met."[3]

A negative aspect, however, to early DOD-contractor dialogue is the very real possibility that performance parameters might become "tailored" to a specific contractor, thereby suppressing innovation and possibly reducing eventual competition. The San Francisco Bay Area firms surveyed overwhelmingly agreed with this contention. The Commission on Government Procurement also noted this pitfall and the subsequent possibility for protest to the Government Accounting Office.[4] The commission felt that the benefits to be gained by closer cooperation with industry did not outweigh the disadvantages. All Bay Area contractors surveyed seemed to have fairly good relations with their customers and expended considerable marketing effort keeping abreast of their customers' future needs. Still, their marketing efforts produced mixed results. Several firms complained bitterly about "pre-selection" of others.

Most firms interviewed had negative comments about the quality of specifications written for government RFPs. Several said that there is always something buried in the specifications that is unrealistic, for instance, a peculiar technical requirement that could boost the price of the end product unnecessarily by a factor

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1. National Security Industrial Association, *Defense Acquisition Study*, Washington, D.C.: National Security Industrial Association, (July 1, 1970), p. 12.
2. *Ibid.*, p. 29.
3. NSIA Research and Engineering Advisory Committee, *A New Approach to RFP's for Acquisition of Army Weapons Systems*, Washington, D.C.: National Security Industrial Association, (March 23, 1973), p. 6.
4. Commission on Government Procurement, *Final Report, Study Group 12, Major Systems Acquisition*, Vol. 1, Washington, D.C.: U.S. Government Printing Office, January 1972, pp. 404, 680.

of ten. Despite the apparent extent of the specification quality problem, several firms stated that once the statement of work goes out, the government acts as if it were etched in stone and is very reluctant to issue changes.

Evaluation Criteria: The main problem in this area is that DAR 3-501 (b) prevents the disclosure of numerical weights (assigned to evaluation factors) in the RFP. Industry complained as far back as 1962 that knowledge of the factor weights was essential to giving the government a proper response to the RFP.[5] A series of comptroller general decisions in the 1960s built up a *de facto* policy which required the government to tell industry what the evaluation factors were (even this was not always done), and what their "relative weights" were.[6] The industry position was best stated by NSIA in their 1973 RFP study:

> Also, the panel unanimously agrees that an aid to fully understanding the program objectives would be to inform the contractors of the weightings. The weightings are an indication of the relative importance the customer places on various aspects of the program. Knowledge of the weightings would indicate which part of the proposal deserves the most attention. . . . Hence, in the areas of most importance, the customer is assured of the contractor's best offer. Not disclosing the weightings merely rewards the contractor who is the best guesser or the one that has had the most influence on the requirements or RFP writers; and contractors in this category are not necessarily the best assurance of a lowest risk program.[7]

The government position expressed to Study Group 6 of the Commission on Government Procurement was that the disclosure of precise weights would result in proposals being ". . . structured in accord with the government bias instead of the contractors' own thinking." The proposals are then evaluated, however, in accord with the government bias, not the contractor's. The government also declared that the disclosure of weights would ". . . stifle innovations by industry and would cause selection 'gaming.' "[8] Presumably the government was saying that its current rules did not invite "gaming." Nonetheless, Study Group 6 recommended the disclosure of weights in the RFP.[9] Study Group 12 disagreed,

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5. Dominic A. Femino and Lawrence M. Smail, "Disclosure of Evaluation Factors and Their Relative Weights: A Continuing Procurement Problem," *National Contract Management Journal*, Vol. 11, No. 2 (Winter 1977-1978), p. 15.

6. *Ibid.*, p. 16-17.

7. *NSIA Research and Engineering Advisory Committee, A New Approach to RFP's for Acquisition of Army Weapons Systems*, Washington, D.C.: National Security Industrial Association, (March 23, 1973), p. 8.

8. Commission on Government Procurement. *Final Report, Study Group 6, Pre-Contract Planning*, Washington, D.C.: U.S. Government Printing Office (December 1, 1971), p. 205.

9. *Ibid.*, p. 233.

however, and worried that disclosure of weights could lead to a debate as to the "wisdom" of their specific values.[10] One contractor pointed out that giving the ordinal ranking of four, evaluation factors can be very misleading (for example, 1st, 2nd, 3rd, and 4th could be 27 percent, 26 percent, 24 percent, and 23 percent; or 75 percent, 10 percent, 8 percent, and 7 percent). Recent comptroller general decisions, however, have reinforced the government's position of non-disclosure.[11]

Two other potential evaluation factors which continue to generate controversy are "cost realism" and "past performance." Cost realism is the relationship between a contractor's cost proposal and the government's cost estimate. The closer the two figures, the higher the degree of realism. This factor has been of little interest to government negotiators over the years, and according to the Bay Area industry sample, it is still being ignored, despite paragraph III.C.2 in DOD Directive 4105.62.

"Past performance" is a factor that would seem to be a potentially valuable contractor motivation tool. The fact that it is not currently used (even though nominally provided for in paragraph III.D.1 of DOD Directive 4105.62) is puzzling. Most of the Bay Area contractors sampled felt that past performance should be ranked second behind technical capability, and certainly ahead of price. The president of Boeing Aerospace once declared that: "A general feeling runs through our business that the 'hurt' from bad performance is only temporary, and good performance in the past really doesn't help. Now isn't that strange? One's reputation should be a big selling point. In the commercial world, without a good reputation, you don't last long."[12]

Request for Proposal: According to the Bay Area contractors interviewed, many of the criticisms that have been directed toward the RFP by past studies still exist today. In September 1978 most Bay Area firms interviewed had seen little change in the RFPs sent to them. Many complained about the difficulty in understanding exactly what the government wants. An electron tube manufacturer mentioned one RFP that he had received that had 125 pages, only one of which told him what was being solicited. An aviation-related research firm equated reading a government RFP to wading through a tax code. That company also complained about the endless array of add-ons with which the RFP is burdened:

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10. Commission on Government Procurement, *Final Report, Study Group 12, Major Systems Acquisition*, Vol. 3, Washington, D.C.: U.S. Government Printing Office (January 1972), p. 717.

11. U.S. Comptroller General, Decision B-186001 (Dec 22, 1976), Decision B-187811 (July 29, 1977), Decision B-188871 (October 25, 1977), Decision B-184194. Washington, D.C.: U.S. General Accounting Office, (May 26, 1978).

12. Oliver C. Boileau, "Weapons Acquisition: An Industry View," *Program Managers Newsletter*, (Spring 1977), pp. 11-12.

—One of these days, the government must stop its psychotic submission to the pressure of special interest groups. It borders on the ridiculous, the way that the size of today's solicitation packages have grown out of proportion because of the addition of so many regulations and restrictive provisions. The government imposes all too many restrictions upon the contractor, which are designed to force the prime contractor to distribute "the goodies." The contractor is now supposed to be all things to all people, i.e., OSHA, clean air, the handicapped, the veteran, minorities, minority enterprises, small business, women, foreign trade off-sets, buy American, the subcontracting of certain portions of the work, etc.

Excess data was also still a problem. A supplier pointed out, "data is expensive," to both the contractor and to the government. The majority of the 20 firms surveyed thought that the government asks for too much data. Length of RFPs and proposals were also local issues, but suppliers were not in agreement on the remedies. Less than half thought that page limits should be placed on RFPs, and only slightly more than half advocated limits on proposals, even though most of them concurred that longer proposals lead to longer evaluation periods and to increased costs.

Proposal Response Time: Thirty days is rarely enough time to formulate competitive proposals for a major system. The contractor's bid/no bid decision must be carefully weighed, proposal teams formed, strategy developed, and technical, management, and cost packages written in the remaining few days. Study Group 12 of the Commission on Government Procurement reported: "We found evidence of undue compression of time. This occurred in the . . . proposal time allowed. Our interviews indicate that the government has consistently allowed industry far too little time to prepare proposals."[13] As a result, competition is discouraged; time and money are wasted by contractors trying to do advance work on less-than-perfect information; innovation is time-restricted; and the eventual proposals, coordinated within companies at great cost and expenditure of overtime manhours, will have inevitable errors, complicating the government's evaluation task. In fact, with the present practice in negotiated procurements of advising contractors of all deficiencies in their proposals, much time is lost working out errors initially caused by the rush to submit proposals within the given deadline.[14]

Proposal Evaluation: The Bay Area contractors overwhelmingly agreed that less emphasis should be placed on mathematical equations of numerical assessments and more on judgment of the overall proposal, its critical points, and the reputation and capability of the contractor offering the proposal.

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13. Commission on Government Procurement, *Final Report. Study Group 12, Major Systems Acquisition*, Vol. 3, Washington, D.C.: U.S. Government Printing Office (January 1972), p. 679.
14. *Ibid.*, p. 705.

No other phase of the source selection process has been subjected to so much abuse and subsequent analysis as this one. The government's policy of negotiating essentially with all offerors simultaneously has apparently been the root of many problems suffered by major systems programs in the last 15 years. The fact that the DOD is a "monopsonistic" buyer distorts its bargaining position with industry and compounds the faults inherent in a policy of negotiating with all offerors. Candid negotiations are very difficult when conducted in a monopsonistic environment. There is a very real tendency to tell the government what the contractor thinks it wants to hear. In discussion with Bay Area contractors, gamesmanship was mentioned often, and usually in a derogatory manner.

Simultaneous negotiations with all offerors, then, has led to technical leveling, technical transfusion, auctioning, and buy-ins. The first three are direct government actions toward contractors; the last is a contractor action, but usually government-induced.

Technical leveling results from discussions held by the government with all offerors to identify deficiencies in their proposals.[15] "Deficiency" is a relative concept, however. To government negotiators, a deficiency is any aspect of the offeror's proposal which is not fully responsive to government requirements. Deficiencies are identified by the government and then corrected by the offeror by making revisions to his proposal. Technical leveling tends to minimize innovation and obscure differences in technical approach of the various competitors by guiding all offerors toward the government's pre-determined design specifications. Technical leveling allows weaker contractors to remain in competition by helping to upgrade their proposals. It also encourages hasty changes in all proposals which may have subsequent negative impacts not foreseeable at the time of the revisions.

As proposals become leveled out and their technical differences narrowed, one other factor takes on greater and greater importance—cost. Study Group 12 discussed this and concluded that technical leveling leads to price "shaving" because cost/price is eventually the principal visible distinguishing factor.

Technical transfusion formerly was part of DOD's source selection operating procedures, but is now prohibited by DAR 3-805.3(b). Study Group 12 found transfusion common among source selections of the 1960s. The government imposed transfusion on the prime contractors, and the primes did it to the subcontractors. Study Group 12 also heard industry testify that they withheld their best ideas until the very end of negotiations to avoid having them given to another

15. Commission on Government Procurement. *Final Report. Study Group 6. Pre-Contract Planning*, Washington, D.C.: U.S. Government Printing Office (December 1, 1971), p. 219, and Gerald F. Keeling, "The Games People Play in Source Selection Competitions," *National Contract Management Journal*, Vol. 9, No. 1, (Spring 1975), p. 123.

offeror. In 1972, GAO ruled that: "Obviously, disclosure to other proposers of one proposer's innovative or ingenious solution is unfair. We agree that such 'transfusion' should be avoided."[16]

By 1975, according to some sources, technical transfusion had disappeared. In 1978 a Senate committee report on S.1264 disagreed, however, and laid the blame for current transfusion on the government practice of negotiating with all offerors.[17] Several Bay Area firms backed up the S.1264 committee report. Some said that they had been on both ends of transfusion, but would rather have it stopped completely. Most had high marks for the integrity of the government procurement officials, but low opinions of many end-user agency technical personnel who consistently leak information to their suppliers.

Like technical transfusion, auctioning *per se* is prohibited by DAR. Also like technical transfusion, *de facto* auctioning continues. Again, the root cause is traced back to the requirement for discussions/negotiations with all offerors. Study Group 6 of the Commission on Government Procurement found in its hearings that discussions had an undesirable influence on the area of price negotiations. Successive rounds of discussions as held by DOD were reported to lead inevitably to price auctions.

In Study Group 12 hearings, simultaneous negotiations were characterized as an "excessive use of the Government's bargaining power," and "auctioning." As with technical transfusion, while prime contractors complained about the government auctioning, subcontractors complained about the primes doing the same with them.[18] Bay Area subcontractors echoed similar sentiments. One said, "It is an outright blatant auction, nothing less." Most Bay Area prime contractors admitted conducting "highly competitive price negotiations" between their suppliers. The degree of high-handed treatment by a prime seemed to be a function of his size; the larger he was, the less delicately he treated his subs.

GAO has held auctioning to be illegal, but on the other hand has sanctioned multiple "best-and-finals." In *Neomed, Inc.* the low offeror had been identified by the government contracting officer to be a competitor. The GAO said that this amounted to an auction technique and was strictly prohibited by DAR 3-805.3.[19] This also happened to a Bay Area communications firm. On a highly complex project with considerable uncertainty, the only other competitor came in with a

16. U.S. Comptroller General, Decision 51 Comptroller General 621, Washington, D.C.: U.S. General Accounting Office (March 31, 1972), p. 622.

17. U.S. Congress. Senate. *Federal Acquisition Act of 1977*, Senate Report 715 to Accompany S.1264, 95th Congress, 2d session, (1978), p. 39.

18. Commission on Government Procurement, *Final Report, Study Group 12, Major Systems Acquisition*, Vol. 3, Washington, D.C.: U.S. Government Printing Office (January 1972), p. 717.

19. U.S. Comptroller General. Decision B-187146 (November 18, 1976), Decision B-186930 (November 18, 1976), Washington, D.C.: U.S. General Accounting Office.

best-and-final offer 5 percent under that of the company interviewed. According to the company president, there was no way that could have happened unless his offer had been "leaked" to the other contractor. In *Rockwell International Corporation*, the GAO specifically stated that it did not think that a second round of best-and-finals constituted an unacceptable use of auction techniques. The GAO likewise upheld an agency's call for a second round of best-and-finals in both *Westpack Product Company* and *Bunker Ramo Corporation*.[20]

Regardless of what DAR and GAO say, most defense contractors charged that they are auctioned continually and that they dislike it. Most complain about the best-and-final offer concept.

The DAR does not "prohibit" buy-ins. They are "disfavored," but allowed. The GAO has upheld the validity of buy-ins on several occasions. In a 1977 decision, GAO again sustained the government's policy permitting buy-ins. The GAO ruled in *Sencor* that the contract award was proper even though the lowest cost proposal may have been "unrealistic."[21]

The government policy of simultaneous negotiations with all offerors in a monopsonistic environment leads to technical leveling, technical transfusion, and auctioning, with all of the above then culminating in industry buy-ins. Such buy-ins, in turn, have led to program costs overruns, schedule delays, performance failures, and considerable political difficulty.[22]

Analysis of the Impact of Four-Step

Let's now look at the ways the four-step source selection process should alleviate some of these problems.

Step 1: Separate technical proposals are solicited, received, and evaluated. Limited discussions are conducted with all offerors for the purpose of mutual understanding and clarification. During the discussions, technical deficiencies seen by the government in the proposals are not mentioned.

Submission of the technical proposal first should allow more time to be devoted just to it, with a concomitant increase in its overall quality. This may reduce industry complaints over inadequate RFP response periods.

Limiting the scope of discussions of technical proposals by not disclosing deficiencies will limit the magnitude of the government's technical leveling efforts. Limiting technical leveling will subsequently inhibit government possibilities for

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20. Decision B-186671 (November 23, 1976), Decision B-187645 (June 15, 1977), Decision B-188542 (August 16, 1977), Washington, D.C.: U.S. General Accounting Office.

21. U.S. Comptroller General. Decision B-188807, Washington D.C.: U.S. General Accounting Office (November 28, 1977).

22. M. J. Peck and F. M. Scherer, *The Weapons Acquisition Process, an Economic Analysis*, Boston: Harvard University Press (1962), p. 43.

promotion of technical transfusion and auctioning. This, in turn, will reduce government sanctioning of contractor "cost optimism" and accompanying buy-ins. Limiting technical leveling will also encourage contractor innovation. It will mean that differences in technical proposals will remain sharp throughout the evaluation process and give the government evaluators distinct choices of alternatives in Step 3. Clear differentiation among technical proposals will enable the government to retain price/cost in its appropriate relative perspective listed in the RFP, and avoid (or reduce the necessity for) price competition, auctioning, cost optimism, and buy-ins. (Quite obviously this is the most crucial area of four-step to the elimination of previous source selection problems.)

Limiting the scope of discussions should also save time previously spent in identifying proposal deficiencies. It also ought to encourage more pre-solicitation government-contractor dialogue and better RFPs. The clearer the government's solicitation documents, the higher the quality of the contractor responses, and the more genuine the competition.

Unfortunately, these benefits have a price. Separating technical and cost proposal submission and evaluation evolutions may lengthen the time required for the source selection process, at least in the early stages. At present, technical and cost packages are submitted and evaluated simultaneously.

Government contracting officers may be overly cautious in applying four-step rules, limiting the scope of discussions so that total communication will be unduly restricted. This could leave all parties frustrated and negatively motivated toward the remainder of the four-step process.

Not being allowed to point out deficiencies to offerors in Step 1 raises the possibility that the government may not get what it wants, and/or that extensive discussions of deficiencies may be necessary in Step 4. If the quality of the typical government RFP does not improve above its present level, this potential drawback is real.

Step 2: Following the evaluation and discussion of technical proposals, cost/price proposals are received, together with any revisions to technical proposals. The competitive range is then established and those offerors not included are notified. Limited discussions are then held on the cost proposals and the revised technical packages.

Submission of the first cost/price package after evaluation of technical proposals will save the offerors much previously wasted effort. Now they can wait to see what revisions will be necessary in the technical proposal before finalizing their cost presentation.

Sequential submission of the cost proposal after the technical proposal will allow more time to be devoted to cost parameters. Uncertainties can be more thoroughly addressed, estimates refined to more probable expected values, and the overall quality of the proposal increased.

The limitation on discussions, which prohibits telling an offeror that his proposal is too high or too low (now permitted by DAR), will discourage auctioning, which will in turn restrict government condoning of buy-ins.

There are two disadvantages inherent in Step 2. Offerors whose technical proposals are unacceptable are not eliminated until after submission of cost proposals. This requires unnecessary effort on their part. Step 2 allows for revisions of technical proposals that have already been revised once. This could lead to "gaming" and discourage "first-and-best" proposals.

Step 3: At the completion of discussions, a "common cut-off" date is set for receipt of final revisions to cost and technical proposals. Evaluations are then conducted on each proposal in total. A single offeror is then selected for negotiation of a contract. Unsuccessful offerors are promptly notified to allow them to release their proposal teams.

The principal advantage inherent in this step is that the "losers" are notified early and can disband their proposal teams for other work.

Unfortunately, early notification of losers also gives them more time with the winner. This could delay the start of the acquisition project and lengthen the process significantly. Also, with proposals being revised, the "common cut-off" holds the possibility for abuse in the finest past traditions of "best-and-final" auctions.

Step 4: After selection of the winner and notification of the losers, a single contract is negotiated. The negotiations, however, must not draw out, nor involve substantive changes in the government's requirements or the offeror's proposal. If a contract cannot be consummated in a timely manner, negotiations may be terminated, and a new winning contractor chosen.

Negotiating with only the winning contractor saves government negotiators considerable time and effort. It also allows the chosen offeror to be frank with the government. Subsequent program timetables, performance parameters, and cost estimates are thus likely to be more realistic. The integrity of the whole source selection should be improved and political criticism should be dulled.

There are two disadvantages in Step 4. In a time-critical situation, negotiating with a single source may give more leverage to the contractor. Even though the government could switch to another offeror, a lack of time may effectively close that option. The final contract may then cost more than it would under normal circumstances. The government may be reluctant to switch to another contractor, even if time is not critical. A switch might be in interpreted as a sign of weakness or indecisiveness, and invite a protest from the originally chosen contractor. The fact that Step 3 designates the winning contractor as basically a "sole source" negotiating partner with the government in Step 4 also has the potential for system disruption.

Conclusions

It is unlikely that any new government regulation or set of procedures can completely eliminate all abuses of past acquisition practices. No regulation can realistically eliminate all factors which motivate contractor buy-ins.

Procedural changes, not new regulations, can accommodate the alleged failure of DOD to properly weigh prior contractor performance. Four-step at least addresses the other principal procedural problems. It changes those past regulatory requirements that not only allowed the abuses, but actually encouraged some of them—leveling, transfusion, auctioning, and buy-ins.

Use of four-step procedures will force more extensive pre-solicitation government-industry dialogue, something urged for years by contractors. Since discussions are limited, offerors need to know exactly what the government wants. It will be in the government's interest to promote clear and well-written RFPs. In the past, RFP quality was not really necessary. The government could get what it wanted by guiding discussions, identifying deficiencies, and having contractors revise their proposals. Government contracting officers may start listing their evaluation weighting schemes in RFPs in a further attempt to aid understanding of the solicitation by industry. The better the RFP, then, the better the proposals will be, and the more effective four-step will become.

Strict adherence to four-step procedures will eliminate technical leveling and technical transfusion; it will greatly reduce auctioning; and buy-ins will also decrease.

Adoption of four-step by DOD is a sign that the Federal Government is indeed serious about trying to improve the acquisition of defense weapon systems.

The Role of the Contract in Systems Acquisition

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Harvey J. Gordon

There are at least two ways of looking at any contract—from the viewpoint of the "seller" or from the viewpoint of the "buyer." The respective motivations and goals can be significantly different. It is akin to two people looking at the same object, but through opposite ends of a viewfinder—not particularly surprising to anyone acquainted with buyer-seller relationships. The effect is as pronounced in major weapon systems contracting as it is in any other kind of contracting situation.

Time and time again, over a number of years, I have found that there are three, four, five, or more viewpoints that abound when the Department of Defense (DOD) looks through its end of the viewfinder at a weapon system contract. Too often, we leave that double image unfocused when the contract is written. My thesis is that if the weapon system contract is to accomplish its intended purpose, then all of us involved in DOD acquisition must focus on the one and same goal.

Intended Contract Purpose

Not all major weapon system contracts are designed to accomplish precisely the same purpose. There are, however, invariants that thread a common course. Despite differences in contracting technique, we strive always for lowest possible cost, timely delivery, and maximum technical accomplishment within cost and schedule constraints.

It appears that, more often than not, the structuring of DOD contracts in order to achieve these goals varies in inverse proportion to our confidence in attaining them. The less we expect to be able to gauge and hold down costs, for example, the more rigid we are inclined to structure the pricing matrix of the contract. Although logic would dictate the converse, we instinctively endeavor to make the contract restrictive or most explicit in those areas of greatest risk and/or uncertainty. It is as if we seek to incorporate into the contract that confidence that is fundamentally lacking in the program. In so doing, we pass on to contractors, through the pressure of competition, risks that only further study, time, and money can define adequately. Apparently, in the program approval process, firm contractual commitments outweigh the confidence placed in in-house assessments.

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I suspect that contracts are modeled, in part, on a "requirement" that exists only in a broad political sense. We want a contract to accomplish that which is necessary to persuade higher authority to grant "approval" to proceed. What is necessary, however, varies from time to time and from system to system. There is no fixed and stated requirement. Perhaps a trend should develop, but the forces that drive higher authority are invariably multifaceted and sometimes contradictory. Absent clear and timely guidance, ambivalence and confusion can enter into the weapon system acquisition process.

Invariably, the user wants a superior product. The technological community seeks sufficient enhancement to justify additional cost, but at an affordable price. Financial managers opt for cost control and visibility. Industry wants business. The Department of Defense generally prefers firm price commitments. Congress searches for cost realism. The program manager insists upon control. Counsel holds out for contracts legally enforceable. All these "wants" might not necessarily be compatible or possible As a practical matter, a major weapon system contract should come as closer as possible to striking a balance between that which is wanted and that which is possible. Personally, I believe the influence of the acquisition community in striking this balance is muffled, and comes too late in the process to play a decisive role.

Nature of the Contractual Commitment

According to convention, the nature of the contractual commitment is a function of contract type. Another view contends that the nature of the contractual commitment is related to the nature of the weapon system, irrespective of contract type. This suggests that contract type, which may alter the apportionment of burden and risk, does not alter intrinsic uncertainties and technical fact. Facts not susceptible to contractual manipulation dominate contractor performance. To the extent that either government or industry disguise or submerge the facts, the outcome is clouded with doubt. It is my contention that objective and realistic factual assessment of "realism," for want of a better word, is a fundamental prerequisite to a meaningful contract.

We will continue to inhibit realism until the allocation of financial resources and program authorizations are predicated upon more sophisticated criteria. Proponents of new systems are engaged in what is essentially an adversary proceeding. Until competition between programs is cast on a footing other than advocacy, this situation will not change. Until it does change, there will remain a variance between the intrinsic nature of the contractual commitment and the stated or purported nature of the contractual commitment. Ideally, contractors should be obliged to accept only reasonable commitments. The defense establishment should determine reasonableness after objective consultation with industry.

The commitments we now extract from industry, frequently under conditions of intense competition, too often reflect industry's hunger for business.

One problem has been in the misapplication of contract type. Too often we enter into fixed-price-type program commitments with higher authority and with Congress. In every major system acquisition, this is the first of two contracts. The understanding with the prime contractor is the second. After this initial program commitment is made, we seek to "flow down" the risk that has been assumed by us, but with less regard for the program realities than common sense would dictate under more relaxed circumstances. The responsibility must fall on those who testify before the Congress and the Office of Management and Budget to set forth more factually the inherent program risks and uncertainties. Until that is done, the unwarranted optimism of program spokemen will continue to percolate down to the contract in the form of dubious contract requirements.

Holding Contractors to Commitments

The preferred way of holding contractors to commitments is to make commitments realistic. Next is to resist the urge to meddle. Lastly, there is the day-to-day requirement to use an effective management information system for ready visibility and quick response capability. Performance and cost incentives *per se* are only nominally effective. The more effective incentive for a defense contractor is the prospect that he will be authorized to proceed with full-scale production.

Milestones, while effective to a degree, cannot be relied upon exclusively. The more meaningful ones often come too late in the acquisition cycle to permit changing contractors. They enhance visibility, demonstrate accomplishment, and prognosticate success or failure. They cannot alter, however, the inevitable course of events. They do not provide new options between the extremes of terminating or proceeding with the program.

Applying financial pressure to a contractor in trouble, such as withholding progress payments, is a solution only in a theoretical context. It presumes that the problem is susceptible to resolution by willful acts or more diligent effort. This assumption is not always valid.

The use of incentives that exceed the range of reasonable expectation is wasteful of incentive effectiveness. Like meaningless milestones, they dissipate scarce resources. Commitments based on "guesstimation" rather than on assessment and experience are, at best, gambled contingencies and facetious criteria for award. A better way to gauge contractor commitment, in part, is to make contractor past performance one of the factors used in source selection. All these tools are valuable if properly employed and considered in a balanced way.

Common Thread of Experience

Major weapon system acquisitions generally experience cost growth. There are many reasons for this. Both the military and industry tend to be optimistic in formulating estimates to serve as the basis for authorization and approval. Escalation in the economy that is not accurately reflected in budget estimates results in increased costs even when all other factors are constant. Tight program schedules dictate some degree of concurrency which, of necessity, results in higher costs. Then, too, it is sometimes difficult to distinguish among costs over target, overruns, increased scope, earned incentive fees, and contract costs versus program costs. Other influences, more subtle and less susceptible to quantification, are premature procurement, uneconomical incremental funding, ineffective cost effectiveness analysis, the natural inclination for sophistication, and intentional gamesmanship.

We often experience the disruptive fallout of late, sometimes arbitrary and, not infrequently, contradictory program budgeting and cost estimating. We always suffer the results of understandable but sometimes grievous overoptimism. Last but not least, there is the backlash of the American public, in the form of congressional criticism, to the high cost of national defense.

The following solutions have been employed at times, in whole and in part. They are difficult to implement in the aggregate.

—Improved in-house cost estimating capability;
—Earlier and better acquisition planning;
—More realistic budgeting and cost estimating;
—Less attention to the "inviolate" nature of initial operational capability (IOC) dates;
—Increased recruiting of superior program managers and contracting personnel, with special attention to their training and retention;
—Effective controls to discourage excessive changes in scope, specifications, funding, and production quantities.

I sincerely believe that the lack of attention paid to these obvious and crucial matters during the planning stage results in our biggest problems. This must be better understood and a new balance struck. It means, as an absolute minimum, greater and earlier participation by budget, logistics, and contracting types in the acquisition planning process. Good weapon system contracting requires the use of the "whole team" and a return to fundamentals.

Role of the Contract in Achieving Program Commitments

Contract structure can help to achieve program commitments if limited to matters resolvable through motivation and the application of productive

resources. For problems that result from limitations in the state-of-the-art, contract structure will not have an appreciable effect. All things being equal, the appropriate contract structure can enhance visibility and the opportunity for more influential governmental intervention. However, the contract structure, in and of itself, cannot fundamentally alter the consequences of technological facts. To be mutually serving, contract terms should be "married" to the technical aspects of a program early in the planning stages.

While we employ the contract as the vehicle for getting commitments from industry at the time of award, improved techniques can make it easier to use the contract as a means to achieve program commitments during contract performance. There is no one assured method. The prerequisites appear to me to be successful concept formulation and contract definition, good specifications, realistic funding, adequate time for performance, flexibility for effective cost/performance trade-offs, responsible source selection and evaluation, and, lastly, good management of the program.

By way of example, contract milestones to help assure that performance commitments are met have been employed with some success. A milestone is either a point in time or a significant event. As an event, it can be a single occurrence, a composite of many occurrences closely related in time, or a composite of many occurrences over a protracted period of time that relate to one another in a logical context. A milestone is viable because it has a signficance that is material and relevant; because its demonstration cannot be disputed; and because it is objective.

The key is to select the right milestone(s). Selection must be a reasoned, studied effort decided jointly by the technical and contracting talents involved, and concurred in by the contractor. The same milestone may or may not be equally valid in the same acquisition program for all prospective contractors. Also important is not where it sits on the critical path of development, but the degree of insight and prediction the milestone adds to management and government visibility. We often search out the spectacular and the apparent for designation as a milestone rather than the more subdued and more subtle event that may be immeasurably more significant. A milestone must be both a measure of quantitative technical progress and a significant early prognosticator of qualitative progress (or lack of progress). The value of a demonstrated milestone may lie not so much in what is shown as in what cannot be shown and the reasons therefor.

I would like to make it clear that milestones alone cannot ensure that commitments are met. Milestones may make it possible to predict success or failure more accurately; they may facilitate earlier and perhaps better visibility; they may even pinpoint in time and *situs* the appropriateness of some corrective action. Conversely, they do not take corrective action, nor do they ensure that the action taken is appropriate or implemented in a timely fashion. They do not offer

the hope that any action taken will overcome the problem—the nature of the problem itself sometimes governs. Then why milestones? Because they are better than nothing! We have always had something like milestones, although they were not formally structured and lacked formal contractual consequence. The major change is a shift in the degree of attention and consequence. We are innovating but not inventing.

I have concluded that implementation of the milestone approach in our weapon system contracts can induce greater cost realism in the negotiating process, and may motivate contractors to manage developmental programs more efficiently. This is because of the financial consequences of working toward milestone achievement without the requirement for a reprogramming of R&D incremental funding. Milestones may also lead to better documentation of the recommendation to proceed with production. But in some instances, milestones can be misleading by demonstrating those things that are important in one context at the expense of those that are far more important in the pure technical context. Milestones are not an unmixed blessing.

Coincidentally, we need to reemphasize two basic principles for further improvement: elimination of IOC dates as time constraints in favor of constraints that reflect the character of the system under development; and greater reliance on actual hardware demonstration rather than mere paper studies. The amount of time and financial resources allowed for validation must be gated to reality. In any instance where this is not the case, we have premature procurement, even though we have gone through all the motions. Department of Defense directives should be revised to provide explicitly for extended definition/validation if completion of the initial effort is inconclusive.

Assessing Program Risk

Two types of program risk are "technical" and "cost." A third risk, timeliness of performance, is a function of these two; it is not susceptible to separate analysis. While a like argument might be made for technical and cost risks, there are cost risks completely distinct from those associated with technical effort (i.e., inflation, abnormal escalation, shifts in the labor market, and tax structure).

We have never been completely successful in accurately assessing technical risk because, regardless of our good intentions, DOD continues to place undue reliance on paper studies and imposes arbitrary time constraints within which to resolve technical unknowns, thereby increasing concurrency between development and production. There is sometimes a paucity of articulate and objective contribution from industry and the services, both of whom are inherently optimistic and highly motivated to proceed at the earliest possible time. These complementary forces serve to mask the true degree of technical risk. When couched in an environment of intense competition, realistic risk assessment is late to surface.

Cost risk, on the other hand, is more discernible. It goes relatively ignored only because we find it expedient to disregard it until it assumes the proportions of a complete impasse. Our budgeting technique—from authorization through appropriation right up to apportionment—is predisposed to be unrealistic. Decisions in the budget cycle are frequently made without due regard for contractual implication. Cost assurances are solicited that bespeak political rather than technical reality. We are gamed by contractors who mask cost growth right up to the point of no return.

There are techniques to offset some of the risk passed on to industry. When these arrangements are used to make adjustments to the contract, however, we come under severe public and congressional criticism. The result is that the contracting officer withdraws from devices which can be characterized as "bail-outs" or "golden handshakes." They are difficult to understand and virtually impossible to explain. Instead, we increasingly turn to built-in contingencies and higher ceilings which, while they are admittedly safer, are not nearly so effective.

Effect of Concurrency on Risk

In trying to define success, we run into a number of difficulties. If by success we mean the product came in at the contracted price, then: Was the contract price fair and reasonable? If we mean on time, then: Did we really need it by that date, and how much could have been saved had we been willing to slip delivery? The effect of concurrency is impossible to gauge unless we can answer both these questions. There are instances where concurrency has resulted in added cost and degraded performance. Conversely, there are instances where it has saved money and improved performance. In all instances it generates increased risk, and therefore must be given careful consideration.

Concurrency results in greater risk because of unforeseen and expensive technical unknowns. By contract structure, we can shift that risk (at a price) to the contractor; we can share in it; or we can assume it in its entirety. Reality seldom permits us to avoid some concurrency, otherwise we would deliver obsolete weaponry. Therefore, the issue is not concurrency versus no concurrency,but the *degree* of concurrency. It seems to me that the minimum essential degree of concurrency offers the greatest chance of orderly development with the least government risk. In the "real world," however, this may be impractical. Concurrency, unlike "competition," cannot be held out as having an absolute value. There are instances where some degree of concurrency is desirable; in other instances, it may not be.

We seem to be striving (even in the asking of these questions) for a set of principles having universal applicability, whereas I believe the emphasis should be on our processes. It is necessary to differentiate between stated values, goals, and

truths; they are not one and the same. Minimizing concurrency can be a policy goal. Minimum concurrency may not, in every instance, be the best way to proceed. We should focus on how to reach the right conclusion in a documented and orderly fashion. Unfortunately, we too often start with the conclusion and concentrate only on how to best fit the facts to it.

Reasons for Cost Growth

Some cost growth is real and some is artificial. During intense competition, it is not uncommon for both industry and the military to display unwarranted optimism. The services compete among themselves, and within each service; there is intense rivalry among the sponsors of the various systems. Within industry, there is intense competition for major weapon system contracts. Not infrequently, and most likely through over-optimism, we target the initial cost of a system much too low. Then, when costs approximate what should have been the initial estimate, we are confronted with an apparent cost growth. This type of cost growth does not lend itself to easy explanation or control. Realism must be applied at the time of cost estimation for program acceptance.

Another cost growth factor is the incurrence of cost between the contract target and ceiling price. This is cost growth by definition only. If we are diligent and resolute in negotiation, the contractor is driven down to a minimal target cost. By so doing, we increase the "criticism exposure." If the contractor was correct (the target cost should have been higher), we are both targets of criticism for subsequent cost growth. Even in competition, this inconsistency is built into the system. Who would wish to explain to the critics of DOD the reason and logic for negotiating a contractor's price *up* from the competitively quoted price?

A third cost growth factor is that associated with higher costs for the same effort. We label this "inflation." It is not budgeted for fully. We are urged to negotiate it out of the contract as a contingency cost. Nevertheless, it does exist.

A fourth cost growth factor is new work or added scope. Some would add to this change orders, both government- and contractor-inspired. While an increase, it is not cost growth, but rather the pricing of factors beyond our knowledge at the time our original estimates were compiled.

What remains is all that should be labeled, in my opinion, true cost growth or "overrun." It is the incurrence of additional cost to do that which was already priced at a fair and reasonable price. It can result from inefficient management, shoddy workmanship, poor design, ineffective cost control, cheating, buy-in, technical unknowns, or poor estimating.

Reasoned use of contract clauses limiting profit and ceilings on engineering change proposals can give a contractor incentive to minimize certain activity, but such use will not completely eliminate the activity. Reliance on fixed-price-type

contracts negotiated in a competitive environment is another approach to the same end. Rewarding good management and penalizing poor management by weighing relevant contractor past performance in source selection can be considered a third approach. Also, rejecting shoddy workmanship, insisting it be corrected at no expense to the government, and better independent cost estimating would serve to further guard against buy-ins and built-in overruns. However, even these measures are not guarantees. The potential factors and the possibilities are so varied and numerous as to be beyond the range of effective control. Therefore, it would seem unrealistic to express program cost as a finite figure, although that is precisely what we do. Were it only possible to talk and budget in terms of a range from least to most probable cost!

Real controls on cost transcend mere contractor efficiency or attitude. What is unconscionable cost growth should be measured not in terms of absolute dollars or percentage of increase, but in terms of associated cost and technical risk factors. A 10-percent cost growth in fabrication of a canteen over a 3-month period is more deserving of criticism than a 50-percent cost growth over 7 years for a complex weapon system. What we really want to know is whether or not the cost growth was avoidable. We want to know if it was built in. We want to know if the type of contract may have contributed toward it. We want to know approximately how much cost growth may be incurred irrespective of inflation.

To some general degree, we know the answers to these questions. We know which situations are more predisposed to give rise to cost growth even though we cannot quantify that growth. We also know that cost growth is but one of many factors by which success or failure of a program can be measured. And we also know that, in the abstract, cost growth (great or small) tells us little, if anything. Too often we are preoccupied, for political reasons, with cost when we should in fact be concerned with *value*.

Knowing the constituent elements of an increase in cost might add to overall understanding, but it does not contend with the problem of avoiding cost growth. In this regard, the following measures must be reemphasized both in policy and in practice:

—Develop an independent cost estimate to be considered during the source selection and evaluation. It should be the benchmark from which we test cost realism for every offeror's proposal, as well as the benchmark from which we test "most probable costs" against proposed cost. We must deal with not the lowest price, but rather with the most realistic cost to ensure against buy-in or unintentioned contractor over-optimism.

—Strip the request for proposal of every non-essential item to simplify the cost and time required to be responsive. This can be achieved by insisting upon less detail across-the-board, and more in-depth detail about selective significant

items. Pay more attention to prior performance than to promised performance, especially in the area of management and cost control. Ask for fewer options or bid combinations to reduce the cost estimating and planning effort. This could also make possible a reduction in the time required for evaluation and negotiation, during which offerors must keep intact organizations and facilities, frequently at DOD expense.

—Hold the successful contractor to his promises, not only in the technical realm and in terms of total cost, but also to the incremental funding plan. We should not adjust the incremental funding plan without good and sufficient reason, and then only with due notice. The funding plan is a contract between DOD and the Congress. It is based on what the contractor(s) has stated to be fair and reasonable. Accordingly, while we will ultimately reimburse the contractor for all necessary, reasonable, and proper costs, the contractor should shoulder the responsibility and the inconvenience for disrupting that plan through inefficiency, poor planning, poor management, poor design, or poor cost control.

—Structure the commitment to proceed with production on demonstrated accomplishment or milestone demonstrations. Delay incurred in the successful demonstration of a developmental milestone should entitle the government to a commensurate delay, in whole or in part, in exercising commitments for production, with no adjustment in the price of the production option(s).

—Minimize concurrency between development and production. Where economically feasible and time permits, "fly before buy." Where cost is not prohibitive, parallel, competitive demonstrated accomplishment should be shown, if not of the entire system, at least of high-risk brassboards. This, together with protracted contract definition, where essential, and a willingness to defer IOC if necessary, will minimize the risk of cost growth and technical uncertainty to both the government and industry prior to final commitment.

—Change fundamental negotiating techniques, especially in the area of pricing overhead costs. Effort should not be confined to the ratio of indirect to direct costs; rather, examine the cost elements of overhead (what drives these costs) and emphasize negotiation of what they should be rather than allowability.

—Explore greater use of the award-fee concept so as to reward contractor efforts, particularly in the realm of management effectiveness, for a better-than-average job. Keep a scorecard on those areas of performance where it is desirable to encourage performance, but where it is impossible to set forth objective criteria for management.

—Give contractors greater flexibility, but stop short of disengagement. Within the structure of our contracts, there should be incentives against late or excessive numbers of changes (ECPs), and positive incentives for effective cost trade-offs.

These techniques are by no means all inclusive. We should use them all, individually or collectively, with intelligence, discretion, understanding, and an overriding concern for their consequences.

Contract definition can also contribute to the cost growth, although it is specifically intended to achieve the opposite effect. It can do so in three distinct ways:

—By creating over-confidence in our ability to develop and fabricate hardware under a fixed-price-type contract;

—By leading to intense price competition, which amplifies rather than diminishes the aforementioned state of mind;

—By resulting in our conducting our affairs within a time constraint and with contract structures that are, in retrospect, not ideally suited to the facts.

From this we can conclude that incomplete or inadequate contract definition is worse than none. Where possible, it should include brassboarding of selected high-risk components. Regrettably, we rarely seem able to afford the funds and time to do it right.

Although there may be common reasons for cost growth, it does not necessarily follow that there are common solutions. One solution, which is common and always effective, but not necessarily viable, is "termination." Some, but not all, cost growth is inevitable to some degree. The problem is in striking a balance. What we have not always done is to ensure earlier recognition and earlier aknowledgment of cost growth by the contractor. I think if we had done more of this in the past, we would have responded to cost growth problems by more intensive and more timely analysis of trade-off possibilities with greater effect.

It has been my observation that pressing the state-of-the-art is more likely to result in cost growth. The degree of that cost growth depends on the contractor, the subject area of the art, the degree of enhancement sought, the quality of the government's program management, and the degree of flexibility provided for trade-offs. When pressing the state-of-the-art, there should be commensurate diminution in the degree of concurrency to reduce cost growth risk. There should also be a proportional increase in the depth and scope of the contract definition and validation. There should be a relevant contracting structure to share the risks fairly. There should be a source selection based primarily on technical excellence, not price. There should be realistic budgeting and cost estimating. All of these go hand-in-hand.

Conclusion

In the contractor-government relationship, there is the expressed or stated relationship, articulated in the definitive contract. There is also an implied relationship (usually more reflective of the actual situation and not expressed in the

formal contract) that conditions the manner in which the parties conduct themselves. The implied relationship governs day-to-day dealings and the degree of tenaciousness with which prerogatives, rights, and duties are pursued. In the commercial sector, the difference between these two relationships is usually accommodated by custom and practice. It is invariably conditioned by behavior patterns that are accepted within a "trade" and that govern the manner in which businessmen normally conduct their activities.

The informality of the relationship between a contractor and the government is different; hence, the degree to which there is disparity between the expressed and implied relationship in major weapon system acquisition becomes crucial. It is imperative that we strive to reduce the degree of disparity—that is, the unfocused double image to which I first alluded.

The acquisition of a major weapon system is a mutual undertaking. Both parties commit to mutually reciprocal obligations by way of conduct, financial contribution, and effort. Often, these obligations transcend the ability of either party to fully accommodate the consequences of default. For large system acquisitions, the financial risk assumed by the contractor in the event of default almost always exceeds corporate capacity to continue as a viable business entity. Conversely, the government has invested costs, time, effort, lost alternative opportunities, and military commitments. We cannot actually tolerate the financial collapse of a major weapon system developer midway in a program for a variety of political, economic, and military reasons. Consequently, realistic assessment forces us to conclude that the parties do not expect to enforce the contract literally, despite the hard bargaining exerted to negotiate the express contract and the great importance assigned to our contractual rights and remedies.

It may well be that the use of a contract to express the intended relationship between the government and the contractor in a major weapon system acquisition is inadequate. Reciprocal and joint relationships in many complex commercial ventures are often expressed in the form of agreements or memoranda of understanding rather than in the form of a contract. There are, however, limited alternatives to our use of contracts for a multiplicity of reasons. It thus becomes imperative that we carefully structure a contract to reflect a rational and balanced view of what the parties are capable of achieving, expected to achieve, and required to achieve. We should avoid a posture where there is no alternative to strict legal formality, the consequences of which neither party intended or desired. In contracting for a major weapon system acquisition, the expressed and implied desires of both parties must be merged to minimize the difference between what is stated and what is, in fact, intended. That should be the goal common to all our contracts.

This could result in more lenient, more forgiving, and less definitive contracts than a prudent businessman ordinarily would strive to achieve in the commercial

sector. Still, this ought to be our objective, despite criticism, because the analogy between major weapon system acquisition and routine commercial business is, at best, a forced one. To effect such a radical change first requires acceptance on our part of the proposition that technical uncertainties and cost risks attendant with major weapon system acquisition ordinarily transcend the resources of industry. To the extent that we continue to use conventional contracts in situations where typical contract rights and remedies are not practical or viable, we must relax formal contract commitments to permit performance in an environment that is less adversary in nature and more akin to that found in mutual and joint undertakings. The alternative is to learn to write and negotiate contracts that can be literally enforced as written—and that is not all easy to do in today's environment.

We have learned the lesson well that there is little solace to be found in unenforceable rights and remedies, bitterly bargained for and highly priced. There is a lack of credibility in outlandish promises that are neither intended nor possible to fulfill. One's confidence is misplaced when one relies upon legal rights and remedies to acquire that which is neither reasonable nor possible to attain. While the pendulum should not be swung back so that all development is conducted on a cost-reimbursable best-efforts basis, it seems to me that an absolute prerequisite for successful conduct of a major weapon system acquisition is a fair and reasonable contract—a contract that realistically prices the effort, fairly prescribes what is expected, and sensibly apportions the implicit technical and financial risks. To achieve this requires, as a prerequisite on the part of industry, the courage to stand up to its convictions; and, on the part of government, the courage to stand up to its critics. There is no doubt in my mind that, given this resolve, improvement is possible. ‖

43 Independent R&D: Key to Technological Growth

David D. Acker

Independent research and development (IR&D) represents the lifeblood of technological growth in the defense and aerospace industry in the United States. It has made a major contribution to our technological leadership, and it might be called the keystone for our national security and economic vitality since World War II. Simply stated, IR&D and the related bid and proposal (B&P) effort have advanced technology, promoted competition, and fostered economic development.

The IR&D performed by industry, both large and small firms, is not part of any government "program." This fact does not appear to be obvious to many of its critics, who tend to view IR&D as a giveaway program or a subsidy. The truth is that IR&D is quite the opposite. It is company-initiated and company-funded research and development undertaken to improve the company's competitive position. This improvement is accomplished by:

—Advancing the company's technological capability;
—Upgrading the company's current products and/or services;
—Creating new company products and services.

It is interesting to note that more than 90 percent of the IR&D projects undertaken annually are directly relevant to DOD interests.

The key word in IR&D is "independent." As indicated, the projects undertaken are company-initiated and company-funded. This distinguishes both the nature and value of these efforts. We should never confuse IR&D with "directed" research and development contracted for by the Department of Defense or another government agency. The company-funded research and development efforts will fulfill a vital role only so long as the efforts remain independent of external directions or controls.

Independent research and development is partially reimbursed by the government. It is an indirect or overhead cost shared in by all of a company's customers as described in the Defense Acquisition Regulations (formerly the Armed Services Procurement Regulations), Section 15-205.35.[1]

DOD Objectives

The overall DOD objective in supporting IR&D is to encourage the evolution and maintenance of a strong, up-to-date, and creative technology-based industry, one from which DOD can draw, as needed, new concepts and rapid

1. Defense Acquisition Regulations (formerly the Armed Services Procurement Regulation), Section XV, Department of Defense, Washington, D.C.

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responses on a competitive basis to satisfy specific operational needs. Supporting the overall objective are the following subordinate objectives:
—DOD accessibility to technically qualified contractors who are willing and able to compete for technically oriented contracts.
—Reduced technical risks and development costs through availability of competitive technical options for satisfying new operational needs.
—Superior defense capabilities derived from competitive technical options available as a result of IR&D efforts by industry.

The companies that provide technically based products and services, whether for the government or commercial customers, must maintain active in-house research and development programs to survive. Only in this manner can they sustain the capability to respond with a minimum delay to customer needs. The growth, even the survival, of contractors may be dependent upon acceptance of their products and services in a highly competitive environment. If a company is to grow or survive, its management needs the freedom to determine what has to be done to keep it in a competitive position. Management must assume responsibility for balancing research and development efforts against the obvious competitive implications of incurring the consequent added costs. The responsibility is an awesome one for the management of any enterprise.

From a DOD viewpoint, support for the IR&D programs complements contract-supported research and development aimed at improving the technology base. By supporting the IR&D efforts of industry, DOD is able to augment the capability of its own personnel to institute and judge original exploratory effort. Companies are able to recover, as an allowable business expense in their government contracts, a closely controlled portion of the research and development funds expended for IR&D projects. The allowance is small, usually less than 2 percent of contract value; however, DOD has found that payoffs of IR&D can be substantial. When a company is aware of future DOD needs:
—More technology can be gained for each R&D dollar expended.
—The technical risk associated with each new product or service is reduced.
—The development time for each new product or service is shortened.

Who Pays for Research And Development?

The purchasers of products in the commercial marketplace—whether those products be television sets, automobiles, lawnmowers, or other items resulting from modern technology—pay the cost of initial development and later product upgrading. [These costs are recovered by the manufacturer by prorating them over the anticipated number of units to be sold.] As a customer in the commercial marketplace, we benefit from the manufacturer's research, development, and upgrading efforts.

When a company does business with the government, the situation is not as simple as the one occurring in the commercial marketplace. A company that sells its products to the defense department is subjected to the restrictions specified in the Military Procurement Authorization Act and the Defense Acquisition Regulations (DAR).

Who Pays for Manufacturing Technology?

In a recent memorandum to the military departments, the Defense Logistics Agency (DLA), and the Defense Contract Audit Agency (DCAA), the Deputy Secretary of Defense for Acquisition Policy, Dale W. Church, set forth current policy relative to the inclusion of efforts involving manufacturing technology under IR&D costs. Contractors have alleged that some DOD review teams are suggesting that manufacturing and production engineering costs be included as a part of the IR&D costs. The memorandum clearly states that if such a misclassification occurs, the IR&D costs will be overstated. Since there is a ceiling on IR&D costs, "the net effect is that contractors must either take greater cost disallowances or reduce the effort they put into production engineering." Viewed in terms of constant dollars, IR&D has already fallen below the level established many years ago; therefore, any actions that tend to cause further reductions "are very undesirable." DOD has been striving for some time to encourage contractors to increase their efforts in manufacturing and production engineering. If these costs are included in IR&D costs, it will tend to reduce, rather than increase, these desirable efforts.

When DOD was developing the present cost principle on IR&D, the Defense Contract Audit Agency sampled the various types of technical efforts being performed outside IR&D. Based on the results of the DCAA study, DOD developed its present definition of IR&D. Manufacturing technology was not included because it does not normally relate to products or services that become a part of the production line intended to be sold to a company's customers. Thus, DOD sees no reason to revise the policy adopted in the late 1960s. Mr. Church understands that some companies may follow the practice of placing certain manufacturing technology projects under their IR&D program. The DOD does not intend to preclude this; however, the best approach for a contractor is to include the costs in other overhead accounts. "We consider this to be appropriate, except when a project clearly falls within the definition of IR&D," the DOD memorandum states.

Military Procurement Authorization Act

The DOD must comply with the Military Procurement Authorization Act of 1971, Public Law 91-441.[2] This Act sets forth how contractors may recover a portion of the costs of IR&D, as well as a portion of the costs associated with bid and

2. Military Procurement Authorization Act for Fiscal Year 1971, Public Law 91-441, Section 203, Appendix C.

proposal (B&P) efforts. IR&D costs are not usually recovered from the government by including them in the price of the product, except for such major projects as the development of an aircraft. IR&D costs are written off by defense contractors each year as an overhead cost; in fact, the financial accounting standard on IR&D requires it.

It is important that the basic difference between IR&D and B&P efforts be clearly recognized. IR&D efforts are primarily exploratory in nature. They are focused on the advancement of technology and on anticipated needs for various military products or services in the future. The development effort is subjected to a periodic evaluation by the contractor performing the work to determine whether adequate progress is being made, or a new or different approach is needed.

B&P efforts are concerned specifically with satisfying current defense needs through application of the company's expertise and technological capability, thus ensuring the successful development and production of a new military product or service. The proposal must demonstrate that the company has a complete understanding of the technical problems involved, and the ability to cope with them. To do so, the proposal must describe the company's concept of the design of the product or service to be furnished. Also, the proposal must discuss the merits of the selected product design versus the alternative designs that were considered.

The technical effort involved in preparing the proposal generally includes such activities as conducting studies, performing design calculations, computer modeling and constructing prototypes. The B&P effort also includes conducting briefings, engaging in negotiations, and responding to inquiries from the procuring organization. The scope and timing of B&P effort is difficult to forecast because the company is normally responding to an evolving government need.

The IR&D and B&P efforts should not be tied together. They are not the same kind of effort, even though the same technical experts may be called upon to support either type of effort. As explained above, the IR&D and B&P efforts are performed for different reasons. IR&D efforts can be planned. However, B&P efforts—because they result from specific and sometimes unpredictable customer requirements—cannot be planned as rigorously.

The DOD negotiates dollar ceilings for recovery of IR&D and B&P costs with the companies that develop and produce military products or services. According to the law, DOD must negotiate advance agreements with all contractors, be they prime or subcontractors, who received in excess of $2 million from the DOD for IR&D and B&P in the preceding company fiscal year. Also, the law requires that only those costs having a potential relationship to a military function or operation be allowable.

The contractors do not receive any direct payments for the IR&D and B&P costs at the time they are deemed allowable. When the military products or services are sold to the DOD in the year covered by the agreement negotiated, the contractor recovers an amount up to the dollar ceiling previously negotiated by including the allowable cost as a factor in the price of the products sold. In a year when the contractor has no defense contracts, the DOD does not incur any of his IR&D or B&P costs.

Defense Acquisition Regulations

Paragraph 15-205.35 of the Defense Acqusition Regulations (DAR) establishes cost principles and procedures regarding IR&D negotiations. It states that "a contractor's IR&D effort is that technical effort which is not sponsored by, or required in performance of, a contract or grant." The technical effort must consist of projects falling within the following three areas:

—Basic and applied research;
—Development;
—Systems and other concept formulation studies.

The technical effort cannot include that which is expended in the development and preparation of technical data specifically to support the submission of a bid and proposal.

The DAR also requires the negotiation of advance agreements, as described previously, and the establishment of ceilings for allowability of IR&D and B&P costs for the following fiscal year. In negotiating the ceiling, particular attention is paid to such factors as:

—The results of the annual technical evaluation of the contractor's IR&D program;
—The relevancy of each IR&D project to a military function or operation;
—The contractor's projections of his sales for the coming year and the scope of his IR&D program during the previous year.

IR&D Policy

Department of Defense Instruction 5100.66[3] sets forth the DOD policy for the recovery of the costs by contractors for their IR&D programs and the procedures for administration of contractor IR&D programs in compliance with the DAR and Section 203 of Public Law 91-441. This instruction, which has expired but which is still being observed until a replacement is issued, recognizes IR&D as a necessary cost of doing business, particularly in a high-technology environment.

3. DOD Instruction 5100.66, *Establishment of Policy for, and Administration of, IR&D Programs*, Department of Defense, Washington, D.C., January 7, 1975.

The costs of competition, or the costs a contractor incurs to enable him to compete, are normal costs of doing business regardless of whether the products or services are sold commercially or to the government. In a commercial business, these costs include such items as marketing, advertising, introductory plans, research, development, testing, evaluation, and other costs that focus on entering or increasing participation in a market. The magnitude of such costs ultimately determines the price of the products or services and their success or failure in the competition. The market eliminates the high-cost, inefficient producers. Through such competition, the buyer is offered the lowest price. Essentially, the same process takes place in defense contracting. Those companies whose costs of doing business remain consistently high disappear from the marketplace. The DOD is concerned with the following:

—Ensuring the creation and maintenance of an environment that encourages development of innovative concepts for military products and services that complement and broaden the spectrum of those previously developed by the DOD;

—Developing technical competence in two or more contractors who can then respond competitively to a specific DOD need;

—Contributing, as appropriate, to the economic stabilization of its contractors by allowing each contractor the technical latitude to develop a broad base of technical products.

The policy regarding IR&D and procedures for complying with the law are set forth in the DOD instruction. The instruction identifies the IR&D Policy Council as an organization composed of the assistant secretaries of defense and the assistant secretaries of the military departments that are concerned with research and development. The Council, chaired by the Under Secretary of Defense for Research and Engineering, is responsible for the development and dissemination of DOD policy and for providing the guidance required to administer the IR&D program.

IR&D Technical Evaluations

The DOD requires an annual evaluation of each contractor's technical plans. The basic purpose of the evaluation is to assess the technical quality of each contractor's IR&D program and to determine the potential relationship of each project to a military function or operation. Additionally, DOD requires that on-site reviews of the IR&D programs be conducted with each contractor at least once every 3 years.

An IR&D Technical Evaluation Group (TEG), chaired by a member of the staff of the Under Secretary of Defense for Research and Engineering, establishes criteria for rating the technical quality of each contractor's IR&D program. In addition to the chairman, a designee from each military department—normally the

IR&D manager—serves on the TEG. The TEG establishes the basic format for the contractors' technical plans, schedules submittals of the plans, selects the military department to serve as leader for each contractor's evaluation, and schedules the on-site reviews. The TEG also provides guidance and procedures associated with negotiation of the advance agreements. Each IR&D manager designates the organization within his military department who will be responsible for each contractor evaluation and each on-site review during the calendar year. Furthermore, each IR&D manager ensures effective evaluation of IR&D technical plans assigned to his military department; arranges for, and participates in, on-site reviews for which his military department is responsible; and maintains an up-to-date list for distribution of the contractors' technical plans.

The DOD encourages tri-service participation in the evaluation of technical plans, on-site reviews, and pre-negotiation of advance agreements in order to foster technical interchange and uniform treatment of contractors by each military service. The on-site reviews permit face-to-face technical dialogue between government and industry peers and confirm the rating given to the technical plan submitted by each contractor.

Allowability of IR&D Costs

IR&D costs include not only direct costs, but all allowable indirect costs except general and administrative (G&A) costs. Direct and indirect costs are determined on the same basis as though an IR&D project were under contract. IR&D costs are recoverable by contractors as indirect costs, generally on the same basis as G&A costs. When the G&A cost base does not provide equitable cost allocation, the contracting officer may, by advance agreement, approve use of a different base.

As indicated previously, any contractor who receives payments in excess of $2 million from the DOD for IR&D and B&P in 1 year is required to negotiate an advance agreement with the government. This agreement establishes the ceiling for allowability of IR&D costs during the contractor's next fiscal year. Advance agreements may be negotiated with the contractor's profit centers (those which contract directly with the DOD) that recover more than $250,000 in IR&D and B&P in 1 year. If a company incurs less than $2 million in a given year, the recovery formulas are based upon the prior year's ratio of IR&D costs to total sales or to another acceptable base.

Contractors who meet the $2 million threshold must submit technical and financial data to support their IR&D plans. An advance agreement is then negotiated on the basis of the TEG's evaluation of the plan. Independent research and development projects, regardless of the method of cost recovery, must meet the test of potential relationship to a military function or operation. Responsibility for this determination belongs to the TEG.

The DAR, in compliance with Public Law 91-441, permits companies to appeal the decisions of contracting officers when the IR&D payments are reduced. Therefore, each military department has established an Appeal Hearing Group, whose determination becomes final and conclusive.

The total of the IR&D advance agreements for all the major defense contractors is currently at a level of about $500-$600 million annually. Some critics view this as a government subsidy. This viewpoint is far from the truth; it is really a bargain because it represents only a portion of the defense-related research and development expenditure by industry. In 1978, for example, the DOD received detailed information about some $1,776 million of IR&D performed by the major defense contractors but only $567 million was accepted as allocable to DOD contracts.

The IR&D Data Bank

Each military department is responsible for performing two major tasks within its purview, namely:

—Evaluating the IR&D programs conducted by contractors to the government, from a technical viewpoint, by review of company-prepared IR&D technical plans and/or by participation in on-site technical reviews;

—Ensuring an awareness of the IR&D program results throughout its technical organizations.

The first task has been carried out with considerable success; however, until the early 1970s there has been a problem in successful accomplishment of the second. The IR&D programs conducted by some contractors contain as many as 200 projects. These projects cover such diverse areas of effort as electronics, aerodynamics, navigation or guidance, and computer sciences. In years past, the IR&D technical plans were evaluated by a few qualified people, then filed in storage cabinets. As a consequence, the information was not disseminated to all who had a need-to-know within the DOD technical organizations and, when someone did learn of its existence, it was difficult to retrieve.

The IR&D data bank[4] has alleviated this problem. This bank is located at the Defense Technical Information Center (DTIC)—formerly the Defense Documentation Center (DDC)—at Cameron Station, Alexandria, Virginia. It provides a centralized body of limited technical and management information that enables DOD scientists, engineers, and managers to identify technical projects of an advanced nature being conducted in the defense and aerospace industry. The data bank, developed and tested in 1971 and 1972, was brought into being with the

4. David D. Acker, Office of the Director, Defense Research and Engineering, "IR&D Data Bank Established," *Defense Management Journal*, Washington, D.C., July 1972, pp. 45-48, 59.

cooperation of personnel from industry selected by the industrial associations, and with the assistance of several companies that voluntarily agreed to test the system being developed and to help debug it. The test program demonstrated that a data bank was feasible and that the proprietary aspects of the IR&D projects conducted by industrial firms could be safeguarded.

The IR&D project data are input by DTIC personnel into the data bank by a generalized input subsystem that performs a computer edit and audit on the input data, updates the master file, and produces a search (or inverted) file. The edit and audit procedures are controlled by a file dictionary and decision tables that conform to the data specifications outlined in Defense Supply Agency Manual (DSAM) 4185.9 titled, *Independent Research and Development Data Bank Input Manual*. The center input subsystem produces feedback documents for use by each contributor to provide a formatted image of his updated record and to identify any errors that may have been made.

The DTIC maintains a file on the project records retrieved by each user of the IR&D data bank. If a company receives a Patent Office secrecy order affecting one or more of its IR&D projects, it notifies the DTIC. The DTIC then deletes the records from the data bank. Each prior recipient of data pertaining to the affected records is notified of the issuance of the secrecy order and is requested to destroy all report pages involved.

Data submitted to the IR&D data bank are handled as company proprietary information and are not distributed outside the government. The data are exempt from disclosure under the Freedom of Information Act, Subsection (b) 5 USC 55a. The information displayed on each page of a company IR&D report is considered to be that company's property and furnished for the sole purpose of identifying the subject IR&D project. As such, it is disclosed only to duly authorized government personnel.

The IR&D data bank, although not intended to be a comprehensive, real-time reference system, serves as the starting point for finding out where specific types of technical projects are being conducted and what the status of the projects are. Availability of information on IR&D projects enhances communication between the scientists, engineers, and managers in the DOD and industry. This benefits both parties.

Congressional Reporting

Public Law 91-441 requires that the Secretary of Defense submit an annual report to the Congress concerning IR&D projects and B&P efforts. This report covers only major defense contractors, i.e., those whose annual costs are $30 million (or more), or those who require 5,000 man-hours (or more) of direct audit

work by the Defense Contract Audit Agency in 1 year. Contained in the report are the following:

—A listing of companies with which IR&D negotiations were held during the reporting period and the results of those negotiations;

—Defense Contract Audit Agency statistics on IR&D and B&P payments made to major defense contractors;

—The manner of DOD compliance with Section 203 as well as a statement of any major policy changes proposed in the DOD administration of the IR&D program or the B&P procedures.

In Fiscal Year 1978, the total cost of IR&D and B&P to the Defense Department was $1.106 billion. Of this amount, $107 million was borne by foreign military sales, leaving the DOD cost at $999 million. This cost was based upon defense sales of $28.3 billion—an increase in sales and IR&D and B&P costs of about 9 percent from Fiscal Year 1977. As indicated previously, the IR&D and B&P costs were not directly funded by the DOD. Rather, these costs were included in the cost of the defense systems and equipment procured by the military services.

Recognition of IR&D Within the Government

Dr. Malcolm R. Currie, former Director of Defense Research and Engineering, recognized the importance of IR&D when he said:

> IR&D is absolutely essential to the quality of defense RDT&E and weapons acquisition. . .I believe its "independence" must be maintained. It is the heart of a competitive and competent industrial base. . . It is well managed, and excellent visibility is provided to the Congress. It pays for itself many times over.[5]

Former Senator Thomas J. McIntyre appeared to share this viewpoint for he stated:

> I am convinced that the investment we (the U.S. Government) make in independent research and development is not only prudent but essential. It is one part of the total investment to preserve our technological leadership and it is one that has paid rich dividends.[6]

Former Senator McIntyre also recognized that:

> The purpose of IR&D funds is to make sure there are qu[illegible]ified bidders to propose on DOD programs. It is the price we pay to make

5. Dr. Malcolm R. Currie, Director, Defense Research and Engineering, *The FY 1976 Program for Research, Development, Test and Evaluation*, submitted to the Congress, April 9, 1975, pp. 1-13.

6. Senator Thomas J. McIntyre, Chairman Subcommittee on Research and Engineering, after reviewing *The 1976 DOD Annual Report of the Congress on IR&D Costs* in the fall of 1976.

> sure we have companies that are in the forefront of technology and prepared to bid on new projects. . . . In my judgment the present system strikes a good balance between control and flexibility.[7]

Dr. William J. Perry, Under Secretary of Defense for Research and Engineering, in a statement to the Congress in February 1979, stressed the importance of maintaining a technological lead over our adversaries and the vital role of the IR&D conducted by U.S. industry in so doing. He added:

> While it is difficult to get precise information about the Soviet Union's Science and Technology program, we know that their leadership gives it a very high priority, and I estimate that it is about twice the size of our own program. However, the Soviets have no equivalent to our IR&D or commercially sponsored R&D, so it has been difficult to draw firm conclusions about the effect of this pending disparity. . . . A key objective of our Science and Technology program is to prevent technological surprise; that is, to insure that the Soviets do not achieve a militarily significant breakthrough in a new weapon system before we do, and we have felt comfortable with our ability to do so in the past. However, because of the intensive Soviet commitment to defense technology and the secrecy with which they cloak their activities, it will be much more difficult to achieve that objective in the future than it has been in the past.[8]

The importance of IR&D in this environment cannot be overestimated.

Recognition of IR&D with Industry

Some of the industry viewpoints on IR&D are contained in a letter to the chairman of the Senate Subcommittee on Research and Development from the Tri-Association Ad Hoc Committee on Independent Research and Development and Bids and Proposals[9] in the Fall of 1975. The selected comments from the letter are shown below. They are still pertinent.

> The majority of IR&D work (some 80 percent. . .) lies in the areas of Applied Research and Development, i.e., in the application of new technology to operational requirements. This Nation's

7. Senator Thomas J. McIntyre, Chairman, Subcommittee on Research and Engineering, after reviewing *The 1978 DOD Program for Research, Development, Test and Evaluation*, submitted by the Director, Defense Research and Engineering to the Congress, January 18, 1977.

8. Dr. William J. Perry, Under Secretary of Defense, Research and Engineering, *The FY 1980 DOD Program for Research, Development and Acquisition*, submitted to the Congress, February 1, 1979, pp. 4-5.

9. The Tri-Association Ad Hoc Committee on IR&D and B&P (chaired by Thomas J. Murrin, President, Public Systems Co., Westinghouse Electric Corporation, and composed of representatives from the Aerospace Industries Association, the Electronic Industries Association, and the National Security Industrial Association) letter to Senator Thomas J. McIntyre on October 28, 1975.

technical strength lies precisely in this area. Often, in the past, new technology has first emerged overseas; but its efficient, effective application to cost-competitive operational systems or hardware has first been accomplished in this country. IR&D is the early R&D most tightly coupled to potential producers of end-terms, and it is intrinsically stimulated and urged by company managements toward the realization of operational devices and systems, rather than indulged as a leisurely conduct of technically elegant work....

IR&D work, contrasted with contracted R&D, is characterized by its extreme flexibility (easy for a company to start, redirect, or stop) and by its relatively low cost, since its in-house management eliminates the need to add the administrative overlay necessary to furnish the formalized financial data and technical reporting attendant to contract R&D. These attributes are highly synergistic. There is no external customer concerned with any potential for criticism of his judgment in awarding a contract for work which later proves to be incapable of achieving the desired result. Such concern, which extends and complicates the contract award process and inhibits speedy redirection of contracted R&D work, is essentially absent in IR&D work. . . .

IR&D gives us an important kind of insurance in that experimenters who may think there is a better approach to the desired capability than that which has been covered by technology contract may be pursuing that alternative within the reasonable constraints—under IR&D. . . .

The smaller companies are reimbursed for their IR&D/B&P costs on a formula basis, which relates allowable percentages for IR&D/B&P to each company's prior history. A small company may thus recover in excess of 10 percent of sales for IR&D costs alone, as contrasted with an average of some 5 percent for the total of IR&D/B&P costs for the major contractors. In addition, a small company with relatively stable sales may recover from DOD its full pro rata share of allowable costs for IR&D/B&P, in contrast to the major defense contractor who normally recovers substantially less from DOD than its full pro rata share of such costs. Of course, as small companies grow, they arrive at the dollar threshold for IR&D/B&P expenditures where they may no longer use a formula for determining the allowability of these costs, but must execute advance agreements with DOD and be subject to the same constraints as other major defense contractors. . . .

Forces inherent in our competitive system operate automatically and effectively to guide independent research and development into appropriate channels and to constrain the costs of these efforts within limits of reasonableness.

> Prudent company management must tailor its independent research and development in accordance with such factors as the competitive environment, its technical competence, the most productive uses of its resources and the relevance of such technical efforts to objectives of the company and its current and potential customers. In so doing, the company management must have the flexibility to evaluate its own research and development on a continuing basis and to redirect immediately the character or level of work on the basis of progress achieved or changes in needs. The ability to react promptly in expanding, curtailing, or redirecting efforts in response to technological discoveries, market demands and economic force is a vital factor in assuring successful and efficient performance of research and development which culminates in the creation of products and services to satisfy commercial and government needs.
>
> External controls, as well intentioned as they may be, interfere with the automatic checks and balances of this system and thus adversely affect the quality and efficiency of these technical activities. In turn, this produces undesirable effects on the quality, timeliness, and prices of goods and services which would have resulted from unfettered creative technical efforts.

In a recent speech, Roy A. Anderson, Chairman and Chief Executive Officer, Lockheed Aircraft Corporation, stressed the need for increased reimbursement for IR&D to stimulate investment in advanced technology. He said that industry R&D has shifted in recent years toward short-term product improvements with early payoffs, and away from basic research and new product development. "It would be tragic to see aerospace go the way of shipbuilding, or electronics the way of steel—victims of technological decline in the face of foreign competition," he continued. Anderson said that IR&D expenses "are recognized as a cost of doing business in the commercial sector—but not entirely so by the government. Some government agencies do share IR&D costs on a partial basis. We in industry long have felt all such costs should be reimbursable and not subject to arbitrary restrictions or ceilings." Anderson would like to have Congress eliminate the capital tax or at least reduce it to pre-1969 levels, eliminate the tax on dividends and create at least partial tax credits for company R&D expenses. The capital gains tax, as well as the dividends tax "discourages investment in general" and "particularly discourages investment in high-technology companies or in new technological ventures where extra risk must be balanced with extra reward," he stated. On the other hand, Anderson said that industry should consider taking such internal actions as may be necessary to improve its ability to innovate.[10]

10. Roy A. Anderson, Lockheed Aircraft Corporation, in a speech before the Wings Club, New York, N.Y., September 1978.

Impact of OMB Circular A-109

Recently, the question was raised, "How will compliance with OMB Circular A-109[11] affect defense-related research and development (R&D) or the DOD IR&D program?" The answer is that the DOD will maintain a separation between technology-base R&D and the R&D devoted to finding solutions to specific mission-oriented needs. In the DOD, the 6.1, 6.2, and 6.3A categories of dollars will continue to support technology-base R&D.

The IR&D activities involve contractor-initiated, product-oriented research and development that is not sponsored by contract; is not required in the performance of a contract or grant; and is not required for the preparation of a specific bid or proposal. The IR&D efforts performed by contractors have been, and will continue to be, a major source of support in the building of a strong technological base in the United States. Over the years, DOD has benefited from these efforts by receiving new technical products and services applicable to defense needs at relatively low costs. Among the recent products stemming from IR&D efforts are the laser gyroscope and the charge-coupled device.

The DOD policy and direction in support of A-109 will ensure a demarcation between IR&D and the R&D directed to the solution of specific mission-oriented needs. For example:

> The mission area analyses reveal long-range technological deficiencies. After the deficiencies have been identified, contractors should be able to focus their IR&D efforts on overcoming them.
>
> With a more clearly defined starting point for each new system acquisition program, it will be possible to maintain a better audit trail. The IR&D efforts and the contracted efforts will be separated more readily.
>
> Provided that the R&D contracts at the front-end of each new system acquisition program to explore alternative design concepts are adequately funded, previous pressure for contractors to pursue near-term solutions to mission-oriented problems should disappear.

Thus, it appears that the issuance of OMB Circular A-109 will be beneficial insofar as it affects the research and development efforts within the DOD.

Summary

The research and development effort performed by the defense and aerospace industry in the United States—an effort partially reimbursed by the government

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11. Office of Management of Budget Circular A-109, *Major System Acquisitions*, Executive Office of the President, Washington, D.C., April 5, 1976.

under the IR&D program—results in a wealth of new technology and information that can be a stimulus for new approaches to satisfying advanced military objectives. Both the military and economic security of our country may well depend upon the efficiency with which this is done. Our advanced military systems, equipment and services must be superior in performance, and available at more reasonable costs, than those produced by our adversaries; IR&D is one means of ensuring they are.

From the viewpoint of an industrial firm, IR&D is being conducted to evolve military systems, equipment, or services that will ensure the maintenance of its market position. To ensure this effort is properly oriented, the firm must engage in a continuing dialogue with R&D personnel from government. This will not only ensure the firm's place in the future, but it will ensure that military-oriented firms in the United States are developing a broad technology-base, one that is capable of supporting our national security needs.

The IR&D program has made some major contributions to our national security and the program has worked well. Therefore, it would be unwise to experiment with this program or to change its essential characteristics. Left alone, the IR&D program will continue to serve as the lifeblood of this nation's technological growth. ‖

Why SIRCS Failed: The Public Record

58

Frank H. Featherston

Cost overruns seem endemic to large government programs. The planning, programming, and budgeting system (PPBS), and the economic analyses by "the best and the brightest" in the Pentagon in the 1960s succeeded only in confirming the national sense of *deja vu* about modern weapon system development overruns. Subsequently, the Congress in 1969 commissioned a comprehensive study of this persistent national problem. The resulting report of the Commission on Government Procurement to the 93rd Congress contained an explicit formula on how to acquire so-called "major systems" with greater efficiency.

The Shipboard Intermediate Range Combat System (SIRCS) was the first major system acquisition program conducted by the government ir accordance with the commission's recommendations. SIRCS was first presented to the 94th Congress (1975-1976). The Office of the Secretary of Defense endorsed this Navy program to the General Accounting Office as being a "model," a conscientious embodiment of the latest principles of efficient acquisition management. The next Congress terminated SIRCS.

To wonder is to begin to understand. The motivation behind this report is to wonder why SIRCS failed. Wondering, by definition, is a preliminary, somewhat speculative and exploratory process. SIRCS, unfortunately, was a highly technical military research and development project whose documentation, by and large, is classified and not readily accessible. . A limited unclassified public record on SIRCS does exist, however; the program is mentioned in published hearings and reports of congressional committees. The research activity reported in this paper examined the information presented in these publicly available documents to see if the reason(s) for the demise of SIRCS could be ascertained. The purpose of this report, then, is to be descriptive, not prescriptive.

Establishing the "public record" of a program on the basis of admittedly less-than-total available information serves two valid objectives. First, the general condition of program status (in this case, the reasons for cancellation) should be evident from reading the public record, as a basic test of the veracity and utility of that record. In particular, the internal management of the affairs of Congress demands that a full and incisive unclassified account of committee proceedings be

Author's Note: I assume full responsibility for this report. I also want to thank Roger J. Curran for making available a copy of the Finch Thesis.

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generated in the public interest as a matter of regular practice to guide the judgments and votes of members. Most of them do not have the opportunity to acquire direct personal knowledge of many specialized issues. The committee system, with its concomitant record, is designed to answer this need.

The second reason for synthesizing this public record of SIRCS is an academic one. It is hoped that, by establishing this first, preliminary frame of reference for the SIRCS cancellation decision, useful feedback and comment will be inspired. Armed with that validation, I will be better equipped to continue my inquiry into more technical and programmatic particulars. The ultimate purpose, through examination of the SIRCS case, is not to find fault but to promote better understanding by deriving a number of lessons learned.

Sources

The congressional hearings and reports reviewed for this report cover activity during the calendar years 1974 through 1978, as follows:

—Senate Committee on Armed Services; Subcommittee on Research and Development, Subcommittee on Tactical Air.

—Senate Committee on Appropriations; Subcommittee on Department of Defense.

—Senate Committee on Government Affairs; Subcommittee on Federal Spending Practices and Open Government.

—House Committee on Armed Services; Subcommittee on Research and Development.

—House Committee on Appropriations; Subcommittee on the Department of Defense.

As a general comment, hearing testimony on behalf of SIRCS was usually presented at a summary management level by the Assistant Secretary of the Navy for Research and Development, or supporting flag officer witnesses. Only before the Senate's Tactical Air Subcommittee (discontinued in the 96th Congress) did lower echelon SIRCS project management represent the program with what appeared to be detailed "flip chart" briefings. Based on the level of detail exhibited by recorded comments and asides in its hearings and the observations in its reports, the Subcommittee on Research and Development of the House Committee on Armed Services displayed the most comprehensive knowledge of the SIRCS program. This indicates that this subcommittee staff received direct advocacy briefings outside of the public hearings process. This, of course, is to be expected for a controversial program. Additionally, the staff members of that subcommittee were experienced Naval ordnance engineers. Likewise, the principal staff interrogator for the Senate Tactical Air Subcommittee was an experienced aeronautical engineer.

The information presented to the public in published congressional hearings has been editorially reviewed (i.e., "cleaned up") by all participants. Classified information has been deleted. Off-the-record remarks and classified information presented during the course of hearings therefore represent points of discontinuity in these proceedings. The course of discussion sometimes is noticeably altered without full knowledge of the reason why.

The Commission's Report

The published report of the Commission on Government Procurement consists of four substantial volumes, representing hundreds of man-years of considered labor in preparation. Even with this initially overwhelming presence, several aspects of the report's form are of immediate interest. Volume 2 makes an editorial distinction between the government's acquisition of "research and development" and its acquisition of "major systems" by discussing them in separate sections. Yet it is at the interface between these two areas of activity, the uncertain zone of innovation in design with technologically possible partial answers, that a formalized synthesis has to be orchestrated as government works with the private sector to define every new "major system."

Fortunately, the choice of structure for the report's organization does not obscure the commission's essential initiative on how to acquire major systems with greater efficiency. The commission mechanism for that is its proposal that each agency conduct a continual, Socratic rationalization of the types of activity the agency must sponsor to accomplish its mission. The agency must specify corporate ends and objectives in terms of functions, not things or means. The important caveat in this intellectualization, the mind trap to avoid, is not to succumb to a premature selection of precisely what physical means (things, hardware) should be specified (and eventually acquired) to achieve the ends desired.

The following illustrates the discipline of the approach. At the highest level of government one might conceptualize that a primary functional objective of the Department of Defense is to prevent the destruction of private lives and property by the acts of foreign sovereignties. How much "Army," how much "Navy," and how much "Air Force" are allocated to this end is a choice of means (ideally, zero-based advocacy should prevail). Another example, on a lower scale is this: Given that Naval ships are vulnerable to air attack, how should the function of air defense be partitioned between general "area" air defense of a group of ships, and "point," or "self" air defense by individual ships (both sub-functions)? This second example, of course, is the functional domain within which configuration choices were made for SIRCS as a "point" air defense system (SIRCS also was required to provide each ship with a capability to strike at nearby surface ship and land targets). Historically, the Navy has made virtually all of its capital investment in the equipment for "area," not "point," air defense (TERRIER, TARTAR,

TALOS, now AEGIS on surface ships; SPARROW, PHOENIX, now AMRAAM on carrier-based interceptor aircraft, supplemented by carrier-based early warning aircraft).

Even as the Commission on Government Procurement did its work (1969–72) the Department of Defense evolved its own stylized process of requiring a sequence of three Defense System Acquisition Review Council (DSARC) decision milestones to monitor the evolution of new major system capabilities. The practical effect of the work of the Commission on Government Procurement, then, was to add another, precursor step, now dubbed "Milestone 0," at which time (as a product of his agency's continual mission analysis) a head of agency could say, "Yes, we need to define a set of conceptual design alternatives to satisfy this critical shortfall in our ability to perform our mission." To avoid the downstream agony of cost overrun, the Commission on Government Procurement endorses the Milestone 0 formalism as a means of ventilating the full range of reasons and implications attending major equipment choices. The commission further stipulates that normally the focused design conceptualization after Milestone 0 should be accomplished for government by competing industrial teams so that the technological genius of the private sector can be brought to bear on the problem to be solved. The role of government in-house technical competence under this scheme is relegated to a position of facilitator of the process, acting as midwife, not mother.

Close liaison with the Congress, of course, is postulated by the commission as an essential part of the early stages of recognizing agency needs. This study of SIRCS is motivated by the desire to help shed light on how that liaison might in fact be accomplished in a constructive manner.

The cultural revolution inherent in the commission's recommendations for major system acquisition is difficult for technically versed government engineers to accept, particularly in a Naval ordnance community that is accustomed to making its own engineering decisions. For decades this engineering administration community has had the responsibility for keeping the Navy updated with equipment that tends not to have direct commercial relevance.

In Appendix C to Volume 2 of the commission's report, one of the commissioners, Frank Sanders, deals directly with his private concerns on the impact of the findings of the commission's recommendations on the future vitality of government laboratories. It is no coincidence that Commissioner Sanders served on the commission while also acting as the Under Secretary of the Navy. His minority report in Appendix C no doubt reflects directly the concerns of the Navy's laboratory and technical community over its well-established role in governing Navy procurements. Because of its size, longevity, and inherent technical diversity, the in-house capability of the Navy has a more dominant influence in that service than the corresponding technical communities have in the

Army and Air Force. Commissioner Sanders was the only member of the Department of Defense executive hierarchy to sit as a member of the Commission on Government Procurement.

93rd Congress

During the 93rd Congress (1973–74) Melvin Price (D., Ill.) chaired Subcommittee No. 1 (research and development) of the House Armed Services Committee. Mr. Price was a legislator well-versed in military research and development matters, starting with his freshman days in the 79th Congress when he joined Carl Vinson's House Armed Services Committee, a product of post-World War II defense unification and complexity. That same year, 1946, Mr. Price became a charter member of the Joint Committee on Atomic Energy, and his support had much to do with the success of the nuclear Navy.

In the spring of 1974, Mr. Price and his subcommittee undertook to persuade the Navy to adopt a coherent "gun policy." The sudden Arab-Israeli war the previous fall contained many convincing combat demonstrations. One of the most convincing was an exchange of GABRIEL and STYX anti-ship missiles, won by the Israelis; practiced tactics by the Israelis with shorter-ranged French GABRIELS provided the edge of success. Mr. Price and committee members felt that the postwar U.S. Navy, with its emphasis on carrier aviation and nuclear submarines, had allowed the surface combat capability of individual ships to atrophy. They were determined to have the Navy's research and development community take remedial action.

The subcommittee acquired the services of Anthony R. Battista, a Civil Service ordnance engineer from the Naval Weapons Laboratory, Dahlgren, Virginia. He was familiar with the technical and programmatic particulars of many of the Navy's neglected surface ship ordnance programs, especially in the area of fire control. Mr. Battista brought insight, knowledge, and strong opinions to subcommittee activities. Mr. Battista was soon joined on the subcommittee staff by Thomas S. Hahn, also from Dahlgren. Both men have earned the respect of industry observers for their dogged pursuit of information pertinent to key issues, and for their openness and availability for discussion and dissent. Throughout the 4-year hearing record of SIRCS, Mr. Battista has clearly stated his preference for using less-expensive gun ammunition instead of the greater-than-$100,000-a-copy guided missiles for "point" ship self defense.

The spring of 1974 also saw appearing for their first times as witnesses before the subcommittee Dr. Malcolm R. Currie, the Department of Defense's new Director of Defense Research and Engineering, and David S. Potter, the Navy's new Assistant Secretary for Research and Development. Dr. Currie acknowledged to the subcommittee the existence of "institutional" problems in the Navy

ordnance development community.[1] Dr. Potter, in turn, knew this community firsthand from 14 years' experience in Naval torpedo development work (1946–60) at the Bureau of Ordnance's Applied Physics Laboratory at the University of Washington. As the senior executive in Navy research and development management, he became a critical observer of the Navy in-house laboratories, and pushed for a clear demarcation in the division of responsibilities between these centers of excellence and private industry.[2]

Dr. Potter was questioned closely by Otis Pike (D., N.Y.) about his concept of the desirability of separating the in-house laboratories from the competitive aspects of procurement,[3] and by Mr. Battista about the population of 118 thirty-year-old MK 68 five-inch gun systems in the Navy, equipment that was still being installed on new construction ships. Mr. Battista maintained that the MK 68's reaction time was too slow for high-speed low flyers and cruise missiles. He was critical of the Navy's failure to develop a lightweight modular fire control system to complement the new 8-inch major-caliber lightweight gun system being developed. A new target acquisition system (TAS) was available from industry, but there were no plans for its deployment by the Navy.[4]

Subcommittee No. 1 capped its FY 1975 authorization drive for a Navy 'gun policy" by fencing $57,500,000 as being available only for surface naval gunnery (excluding the close-in weapon system, which was separately funded). The following excerpts from that year's report clearly indicate the committee's depth of feeling:

> . . . (Dr. Currie) was asked why the Navy was not taking a more systems-oriented approach in their development efforts . . . twenty-year-old gunfire control systems were being installed on our newer ships, that available technology was not being tied together to enhance the Fleet's operational capability . . . . The Committee expects visible signs of progress in solving this "institutional problem" during the coming year. The Committee comments concerning the management aspects of the Department are intended to be constructive . . . [5]
>
> . . . The Committee questions the ability of the naval gun to perform its intended mission. Gun programs have been de-emphasized over recent years in favor of missile programs . . . the

1. H.A.S.C. No. 93-43, Part 4 of 4 Parts, DOD Authorization Hearings, Fiscal Year 1975, p. 3480.
2. *Ibid.*, pp. 3975-3979.
3. *Ibid.*, p. 4011.
4. *Ibid.*, p. 4242.
5. House Report 93-1035, May 10, 1974, p. 39.

> development of a lightweight modular fire control system is essential as a replacement for these systems and will certainly improve the Navy logistic support posture; yet the Navy has deferred the effort after requesting funding for its initiation.
>
> Newer technology programs such as guided ordnance and the 8" Major Caliber Lightweight Gun can provide a significant increase in the effectiveness of naval gunnery. The newer missile systems are characterized by their high cost of expendables. Gun systems permit much lower expendable costs. The Surface Fleet requires the combination of both missiles and guns integrated as a combat system to carry out its intended mission. . . . [6]

The tone of these remarks prophetically underscores the major sticking point that was to develop between SIRCS and this subcommittee over the next several years. Clearly, the subcommittee saw as top priority an urgent fleet need that could be met principally with a systematic use of available technology that gives full recognition to the use of guns as well as missiles.

94th Congress

As the 93rd Congress closed its books in the fall of 1974, David Potter moved up within the Navy's hierarchy to become the Under Secretary. In this capacity he continued to maintain close liaison with Dr. Currie in ODDR&E and all elements in the Navy on research and development matters, particularly on new program initiatives (e.g., the emerging F-18 program, the planned drawdown in laboratory strength).

A new Assistant Secretary of the Navy for Research and Development was appointed in October, an engineer (as opposed to a research scientist) with an industrial background. H. Tyler Marcy had spent his senior years as an IBM laboratory executive, but his early professional experience after the MIT Servomechanism Laboratory had been in activities associated with ordnance system development. Thus, both Secretaries Potter and Marcy were unusually and uniquely well equipped by personal professional backgrounds to provide high-level technical understanding and priority within the Navy to expedite the formulation of a program of specific research and development actions to meet Congress' criticism of the Navy lack of a system-oriented gun policy. Secretary Marcy served as the principal Navy witness for SIRCS for the next three sessions of Congress (through the spring of 1977, the FY 1978 hearings).

In October 1974 the Navy's new Chief of Naval Operations, Admiral James L. Holloway, assigned a surface-combat-experienced flag officer to the Office of

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6. *Ibid.*, p. 51.

the Deputy for Surface Warfare to manage the evolution of a coherent Navy gun policy. Rear Admiral E. W. Carter III, as a captain in 1972, had defended his ship against air attack off Vietnam. He used guns, missiles, and would have "thrown potatoes."[7]

Knitting together the functional needs for future ships to be able to conduct shore bombardment and to strike at other ships, as well as defend themselves against air attack, Admiral Carter led the effort to draft a formal statement of requirements. This operational requirement (OR) was being reviewed and approved, and a new program office was being established as Secretary Marcy, in his first appearance before Congress, began the FY 1976 round of Navy research and development hearings. Two previously established research and development programs—the lightweight intermediate caliber gun system and the advanced anti-ship capable missile defense system—were merged to provide resources for a new program, dubbed shipboard intermediate range combat system (SIRCS).[8] Emphasis in SIRCS was to be placed on meeting the future, not just the present, Soviet-inspired threat. Funds in the amount of $4.5 million were requested for FY 1976 (and $6.7 million in FY 1977) to begin a fully integrated detection-to-kill system that:

> . . . interrelates the role of guns and missiles to avoid unnecessary fire control development redundancy in our self-defense AAW programs. We are not now certain that the ultimate weapon will involve a gun or a missile; it might involve both. . . to meet the requirement. . . for platforms of the mid 1980s and beyond. . . a test gun has been constructed at the Naval Surface Weapons Center, Dahlgren, Virginia.[9]

A feature of Secretary Marcy's presentation to Congressman Price's subcommittee that session was to have Admiral Carter brief the subcommittee on the Navy's efforts to articulate a new gun policy. The presentation was not convincing. As with the previous year's questioning, sharp committee interest was shown in gun systems, the cost of expendables, and disappointment over internal Navy research funding priorities, particularly the lack of support for the lightweight modular fire control system and the eight-inch major caliber lightweight gun.[10] The requested funding for SIRCS, however, was not disapproved in that session's authorization mark-up.

During the summer of 1975 an acquisition strategy for SIRCS was finalized by the Navy and ODDR&E that looked to funding up to four competitive conceptual definition studies with industry. Evaluation of these study results, in turn,

7. H.A.S.C. No. 94-8, Part 4 of 4 Parts, DOD Authorization Hearings, Fiscal Year 1976 and 1977, p. 4625.
8. General Accounting Office Report, PSAD -77-49, January 24, 1977, pp. 6-7.
9. H.A.S.C. No. 94-8, p. 3899.
10. *Ibid*, pp. 4622-4635.

would lead to a planned selection of two companies to proceed past a DSARC I milestone into a validation phase. The "Milestone 0" nomenclature was not explicitly adopted by SIRCS (OMB Circular No. A-109 was available only in draft form at that time. It was formally issued on April 5, 1976). As validated by a GAO review initiated by Senator Lawton Chiles (D., Fla.), formal agency-head approval of SIRCS in accordance with the recommendations of the Commission on Government Procurement never actually occurred. The spirit of the commission recommendations, however, was approximated in the acquisition strategy adopted, and clearly influenced the governing, classified operational requirement, a portion of which is quoted in the GAO report:

> . . . a total, modular combat weapon system capable of being scaled up or down for specific ship platforms. . . . This system will provide a detection through engagement capability. This requirement should be met by a mix of sensor, weapons, command and control, electronic warfare, and decoy sub-systems. New developments in each of these areas are not necessarily required or desired under this OR (operational requirement). Rather, new subsystems developments should be fully integrated with appropriate existing capabilities (or growth variations of present and planned systems) to obtain an optimum system capability and meet defined requirements.[11]

The Navy considered 21 companies to be qualified for SIRCS. Contrary to the commission's wish, small business participation was discouraged. The Navy wanted participants to be able to build parts of any proposed system. The government role was purposely constrained. It specified the projected threat of sea-skimming missiles and other aspects of the tactical future. A library of government furnished information was established at Dahlgren.[12] The rest was up to industry. In order to improve the quality of its solicitation, the Navy circulated a draft request for proposal to industry for comment prior to final issuance. The formal RFP was then promulgated, and seven industry proposals were received just before Christmas, 1975.[13] Evaluation of these proposals proceeded even as Secretary Marcy was preparing for his second experience of presenting the Navy's research and development program to the Congress.

In this second session of the 94th Congress, Secretary Marcy and Admiral Carter walked into a buzzsaw of skepticism when they appeared before Mr. Price's subcommittee to discuss the status of SIRCS. Importantly, staff members Anthony Battista, George Norris, and Adam Klein during the intervening fall had

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11. *General Accounting Office Report*, PSAD-77-49, p. 11.
12. *Ibid.* Reference (8), p. 7.
13. Donald Leslie Finch, "Evolution and Management of Office of Management and Budget Circular A-109," Naval Postgraduate School, Monterey, California, Thesis, December, 1977, p. 165.

conducted an extensive firsthand investigation of fleet readiness. The vocal verdict was "Poor!" Their special, lead-off briefing to a joint meeting of the Seapower and Research and Development Subcommittees of the House Armed Services Committee on February 23, 1976, was a cryptic indictment of the Navy shore establishment's support of the fleet. The staff members' graphic field trip report only served to heighten the subcommittee's interest and emphasis on programs that lead to near-term solution of fleet problems:

> MR. BATTISTA. Admiral, it is refreshing to hear that this year the Navy is adhering to the recommendations of the Procurement Commission. I would like to establish how well the fleet is agreeing with these requirements.
>
> What are you doing to satisfy the fleet's near-term fire control system requirements and I will be specific: We have the MK-56, the MK-53, the MK-70, the MK-68. . . .
>
> What are you doing for these systems? You are spending $16 million, I believe, whatever the number is, for the 1985 time frame. What are you doing for the 1976 to 1980 time frame? . . .
>
> MR. BATTISTA. My answer to that is that I have known Admiral Carter since he was a Commander. His integrity and forthrightness go unquestioned.
>
> I think, frankly, given the resources and the flexibility to do what is right for the Navy, you would see a different approach from him to this whole problem.
>
> THE CHAIRMAN. That is the point. How do you get these resources, unless we have help from within the Navy to help us push the right programs?
>
> MR. MARCY. I think that is my problem to design the resources you need, to face this problem, and I accept that responsibility to do that definition and inform you when we have it designed.
>
> THE CHAIRMAN. We have been able to help before.
>
> MR. MARCY. Yes.
>
> THE CHAIRMAN. I think we can help again, if we had the support within the Navy.
>
> MR. BATTISTA. Mr. Secretary, adding to that: The Navy has had this requirement to do something on its weapon and fire-control systems long before you got to your position, and I got to this position.
>
> It is unfortunate nothing has been done about it, and I mean "nothing of significance."
>
> Admiral Zumwalt, in one of his decision papers a few years ago pointed this out. We have not made adequate progress, as I said yesterday. It is a little disconcerting to get a presentation that highlights what the Federal Procurement Commission asked for as opposed to what the fleet has been asking for, and what the fleet has been needing.

> I think had you come in, Admiral, and said, "This is what the fleet requirements are. This is what we need, so therefore we are going out to take this approach," it might have been a little better received. But the Federal Procurement Commission doesn't have to go shipboard and get shot at. . . .[14]

It was perhaps no surprise that a month later Mr. Price, acting for the whole House Committee on Armed Services, reported a committee recommendation to delete the entire $16.1 million requested by the Navy for SIRCS. ". . . The committee will not support any authorization for a SIRCS in the absence of a program that provides the fleet with essential near term enhancements in capability."[15] *Why Secretary Marcy and Admiral Carter would have formulated* a program for SIRCS that was so divergent to the subcommittee's evident interest is not at all clear and is the central unanswered question on SIRCS.

In conference with the Senate Committee on Armed Services on the FY 1977 Department of Defense Authorization Bill, the House action for full deletion was weighed against Senate action that had only reduced the budget request by $4 million (to $12 million). The compromise reached in conference was to take neither course for SIRCS. Rather, $5 million was added to the Lightweight Modular Fire Control System line, with $2 million of this money designated for completion of the SIRCS concept formulation studies. The committee indicated it would listen to Navy reprogramming requests to continue SIRCS only if the Navy paid "active attention" to its near and intermediate term fire control problems.[16]

SIRCS met a mixed fate in the appropriations process for FY 1977. Emphasizing the general congressional discontent with proliferating types of tactical missiles, with no evidence that the services were working together to establish common use, the House Committee on Appropriations deleted the total SIRCS funding request. Instead, missile commonality between the SIRCS requirement and Marine Corps' interest in a mobile surface-to-air missile system was directed.[17]

Only in the Senate Committee on Appropriations did SIRCS receive favorable support because of the considerable interest of Senator Lawton Chiles who supported SIRCS because of the larger aspect of its example as the first programmatic test of OMB Circular No. A-109. Seizing on the fact that $2 million had been authorized for SIRCS, the Senate Committee on Appropriations

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14. H.A.S.C. No. 94-33, Part 5 of 5 Parts, DOD Authorization Hearings, Fiscal Year 1977, pp. 509, 511, 512.
15. House Report 94-967, March 26, 1976, pp. 74-75.
16. House Report 94-1305, June 25, 1976, p. 38.
17. House Report 94-1231, June 8, 1976, p. 174.

restored SIRCS to full program status by taking it out of the Fire Control System Engineering line and appropriating the authorized $2 million. In its report, the committee pointedly endorsed the Navy's compliance with A-109 and the new weapons acquisition policies of the Department of Defense.[18] The Senate action to appropriate the $2 million was accepted by the House in conference.[19]

This interplay on the FY 1977 SIRCS budget request highlights the fact that other *dramatis personae* in the SIRCS story have been Lawton Chiles, Chairman of the Senate Committee on Government Operations' Subcommittee on Federal Spending Practices, Efficiency, and Open Government, and that subcommittee's previous Chief Counsel and Staff Director, Lester A. Fettig. Mr. Fettig had previous experience with Navy technical matters as a professional member of the staff of the Center for Naval Analysis, a Navy federal contract research center. More recently he had served on the professional staff of the Commission on Government Procurement. In April 1972 Senator Chiles replaced Senator Henry M. Jackson as one of the two Senate appointees to the commission. Senator Chiles has been the Congress' chief proponent for implementing the recommendations of the commission. As already cited, he also is a member of the Senate Committee on Appropriations. In 1977, Mr. Fettig became the second Administrator of the Office of Federal Procurement Policy, established in 1974 as follow-up on a recommendation of the Committee on Government Procurement. He is responsible for administration of OMB Circular No. A-109. Senator Chiles and Mr. Fettig have worked during each recent session of Congress to implement more of the Commission's recommendations (S.1264 in the 95th Congress—The Federal Acquisition Act of 1977; S.5 in the 96th Congress).

The FY 1977 hearings before the Senate Tactical Air Subcommittee in March 1976 gave SIRCS its first general visibility as an anti-air warfare program competing for resources with other programs. The project manager, Commander A. Scott Mobley, gave a detailed briefing on the program, detailing its planned acquisition strategy. A total program cost of $570 million was estimated.

In parallel action for FY 1977, Congress that spring endorsed the Department of Defense efforts to develop a "beyond visual range" air-to-air missile to replace SPARROW by authorizing and appropriating $5 million for this purpose. Built on the technological initiative of the Defense Advanced Research Projects Agency's lightweight radar missile program, this new missile program sought to be responsive to a newly drafted Air Force-Navy joint service operational requirement (JSOR). This JSOR ignored the possibility of sea launch, an eventuality that had evolved without being specified for the predecessor SPARROW.

18. Senate Report 94-1046, July 22, 1976, p. 48.
19. House Report 94-1475, September 3, 1976, p. 42.

The new missile had been assigned by Dr. Currie to the Air Force for development management and became dubbed AMRAAM (advanced medium range air-to-air missile).

In the midst of these FY 1977 hearings and mark-up uncertainties over SIRCS, the Navy in May 1976 completed its source selection process and awarded three concept formulation study contracts, one each to RCA, Raytheon, and McDonnell-Douglas. Raytheon was also an AMRAAM study contractor for SPARROW for over a decade. The final oral progress briefings on their respective concepts for SIRCS were scheduled for RCA, Raytheon, and McDonnell-Douglas for the early weeks of 1977.[20]

95th Congress

Commencing with the 95th Congress, Mr. Price stepped down from his Research and Development Subcommittee chairmanship. Congressman Richard H. Ichord (D., Mo.) assumed the chairmanship. Based on his hearing remarks, Mr. Ichord is dedicated to achieving some measure of control over the "system."

The SIRCS program reached a limbo status as the FY 1978 budget hearings proceeded into the spring of 1977. Ironically, just as the hearings started, the GAO issued its Chiles-requested review of SIRCS that verified that the program ". . . generally is consistent with the Commission's intent."[21] With the conceptual study results becoming complete, it soon became known that each of the SIRCS contractors postulated the need for development of a new surface-to-air missile as the principal weapon of the proposed new systems. The three missile configurations, of course, were substantially different. The SIRCS cost estimate had grown to over $650 million, more than the Navy's newest area air defense system, AEGIS, then in a mature stage of development. Meanwhile, internal budget priorities within the Navy somehow kept the requested funding for SIRCS for FY 1978 to only $3.9 million, not enough to preserve momentum for a major program.

The House Committee on Armed Services again zeroed the SIRCS request.[22] The Senate Committee on Armed Services voiced its concern over proliferating missile types. It denied AMRAAM's request for substantial funding ($23.6 million) and told the Air Force to proceed slowly, using a smaller amount of hold-over funding, and to look carefully at SIRCS/AMRAAM commonality. The SIRCS funding request of $3.9 million was supported by this committee.[23]

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20. Finch, pp. 165-166.
21. General Accounting Office Report PSAD -77-49, cover sheet.
22. House Report 95-194, April 7, 1977, p. 70.
23. Senate Report 95-129, May 10, 1977, p. 22.

When the FY 1978 Department of Defense Authorization Bill went to the Senate floor, however, $13.0 million was added by amendment to make total proposed SIRCS funding of $16.9 million. The intent of this action was to have $3.0 million used for SIRCS/AMRAAM commonality studies, with $13.9 million to be used to continue SIRCS at a realistic level of support.

The final House/Senate FY 1978 authorization bill conference action introduced yet another twist. *If* the Navy would agree to define a new "baseline" specification for SIRCS, that is, have its in-house engineers adopt the best features of the three contractor designs and synthesize a new solicitation, and recompete with industry the next phase, then the $3.9 million requested was approved. This pointed affront to the presumed rigidity of the procedures endorsed by A-109 was specifically detailed as part of Public Law 95-79, the FY 1978 Department of Defense Appropriations Authorization Bill. There was ". . . a clear intent to exclude SIRCS from the A-109 process . . . ."[24]

Preserving the record of congressional schizophrenia over SIRCS, the Senate Committee on Appropriations at first denied all funds for SIRCS because the program was not proceeding *in accordance with* OMB Circular No. A-109.[25] The FY 1978 appropriations conference action between the two houses, however, produced the following provocative stance, which, in turn, became part of Public Law 95-111:

> $3,991,791,000. Provided, that none of the funds appropriated for the Shipboard Intermediate Range Combat System program shall be available unless expended in compliance with existing acquisition policies and procedures prescribed in Office of Management and Budget Circular A-109.[26]

On advice of counsel, the Navy proceeded in accordance with the later congressional direction (PL 95-111). By the fall of 1977 a further evaluation of sources and designs was completed: RCA (the AEGIS contractor, incidentally) was dropped, and McDonnell-Douglas and Raytheon were picked to continue. A DSARC I milestone of August 1978 was set for SIRCS.[27]

Against this backdrop of diametrically opposed and confused congressional action on SIRCS for FY 1978 funding, the FY 1979 authorization hearings were conducted in a strained environment. By this juncture, Rear Admiral T. M. Ward had replaced Rear Admiral Carter as the program's Chief of Naval Operations spokesman, and Dr. David E. Mann, a molecular chemist, had replaced Mr. Marcy as the senior Navy research and development executive. (Admiral Carter

24. House Report 95-446, June 20, 1977, p. 44.
25. Senate Report 95-325, May 18, 1977, p. 99.
26. House Report 95-565, August 4, 1977, p. 43.
27. *Navy Systems Acquisition Symposium: Proceedings and Policy and Guidelines* 27-28 October 1977, National Security Industrial Association, p. 40.

was now Deputy Commander, Weapon Systems and Engineering Directorate, Naval Sea Systems Command, an oversight position still responsible for SIRCS management. The SIRCS project manager, Commander Mobley, had abandoned his uniform in favor of mufti in September 1977 to join Dr. Mann's staff as a Civil Service systems acquisition specialist.)

In hearings before the Senate's Tactical Air Subcommittee, its experienced professional staff member, Charles H. Cromwell, quickly focused on a number of outstanding issues: SIRCS/AMRAAM commonality; SIRCS use of existing SPARROW launchers; and SIRCS use of the Navy's Close-In Weapon System, a high-rate-of-fire gun system about to be deployed in the fleet. Navy answers to these questions all too often appeared soft. The A-109 method that gave contractors the design initiative seemed to come up the culprit. The Office of the Secretary of Defense was formally addressing commonality, the Navy said.[28] A limited analysis of SIRCS/AMRAAM commonality had been performed under contract to the Air Force-based AMRAAM joint project office. Since features of the projected SIRCS threat had been altered by the Navy during the course of this study, its findings were uncertain. The Air Force promised to continue to "work" the commonality problem. Mr. Cromwell had heard that one of the three contractor-proposed SIRCS missile designs would meet the basic AMRAAM requirements. The Air Force witness replied, "Basically yes, sir. Of course, I would suggest that we use AMRAAM for the SIRCS. . . ."[29]

SIRCS hearings before Mr. Ichord's Research and Development Subcommittee were predictably taut. Still voicing grave concern over the lack of internal Navy priority for naval ordnance development, Mr. Battista maintained that while still in the Navy several years earlier he had prepared several of the Navy briefing charts still in use. He was particularly chagrined at the fate of the Modular Fire Control System. Joined in the questioning by Mr. Hahn, a volley of inquiries probed aspects of the SIRCS program: Was distributive processing being considered? What was the government's flexibility under A-109? The nature of the expected threat was questioned: Did the fleet personnel know about and support SIRCS? The climax came in response to a direct question about SIRCS:

> MR. ICHORD. Personally, do you think it's the best way to go?
> ADMIRAL WARD. No, sir.[30]

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28. Senate Committee on Armed Services Hearings, DOD Authorizations, Fiscal Year 1979, Part 7-Tactical Air, pp. 5177-5187.

29. *Ibid.*, pp. 5247-5268.

30. H.A.S.C. No. 95-56, Part 3 of 7 Parts, DOD Authorization Hearings, Fiscal Year 1979, Book 2 of 2 Books, pp. 1202-1236.

In its authorization mark-up that summer, the Senate Armed Services Committee showed its concern over the lack of commonality consideration by SIRCS by deleting that portion of requested funding associated with beginning development of a new missile.

The House authorization bill deleted all SIRCS funding.

The authorization conference decision, passed into law, was to delete the total funding request for SIRCS. Money cannot be appropriated for an unauthorized program.[31] "The first comprehensive attempt to implement the policies of OMB Circular A-109" ended in failure.[32]

31. House Report 95-1402, July 31, 1978, p. 41.

32. Alvin W. Musgrave, "SIRCS and OMB Circular A-109: Changing the Major System Acquisition Process," *Defense Management Journal*, May 1978, p. 24.

Subdivision of Labor Revisited

74

Dr. Franz A. P. Frisch

Industrial specialization, intranational migration of job markets, the search for the optimal size of enterprises, the alleged inefficiency of monster organizations, the utilization of the labor market, optimal purchasing policy, and the prioritization of political and economic goals are just a few of the enumerable problems of our time, where solutions are thought on the micro and macro level. The complexity of those and similar problems is staggering as long as we do not see the possibility of simplifying complex problems down to basic issues. To do this is the goal of my paper, and I will show that the problems listed above can be reduced to two basic issues: the subdivision of labor, and the management of the subdivision.

As initial orientation to the two basic issues, I offer you two variations of an introduction: first, "The Watchmaker's Tale," and second, "An Analytical Sketch." This may help you to decide early on if further reading may be worth your time. The two variations encapsulate all concepts related to the two basic issues which I later discuss in essentially narrative form. The mathematical treatment of the subject, including the framework for a computerized model, will not be included in the present version of this paper.

The Watchmaker's Tale

Once upon a time there was a master watchmaker. He made one watch a year for kings and queens. But soon the princes wanted watches too, and the king ordered him to deliver. So the watchmaker worked day and night—but still he could not fill the orders.

At this point the problem started. But since he was a very smart watchmaker, he searched for a solution and, of course, started with the obvious: Hire many apprentices, and some years hence, each apprentice could also make one beautiful watch a year. So the watchmaker went out to hire many apprentices. But, he could not find enough young, bright and eager beavers able and willing to cope with many years of apprenticeship. This was a big disappointment. In addition, his king let him know that he was not willing to wait for many years until the output of watches multiplied. And this was very bad because in those days, angry kings were most dangerous to the health of common people. Every night in his dreams the watchmaker saw himself beheaded because of late delivery.

Then one night, Frederika, the good fairy from the Taylor family, appeared in the watchmaker's dream and told him: "Subdivide the task of making one watch

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into many simple subtasks; then you can train all the morons in the kingdom—and make as many watches as you want." Then, Frederika's ghost evaporated.

The next morning the watchmaker counted the pieces in hi. watch and found 256, which was exactly the number of working days per year on his calendar. Then in the afternoon he went out and hired 256 morons, and within a month each moron was able to make one piece in one workday, and was very proud of it. Thereafter, every day each moron made his part faster and faster and faster until each moron made more than 1,000 pieces per year. This was again a big surprise to our watchmaker. But since there were enough princes around waiting for a watch, he kept all his morons making parts. Of course, it was not all gain, because he had to have 256 assemblers, timekeepers, quality controllers, rear-end-kickers, and other management personnel. In modern terms, our watchmaker pre-empted the learning theory and invented the overhead. Nevertheless, he became a very rich watchmaker and the richer he got the richer he wanted to be. So he hired 2,560 morons and subdivided each part into 10 very small specific subtasks. Now his output exploded to 100,000 units per year and he was able to sell watches to all burghers and even to peasants. But instead of getting richer, he got poorer because his overhead soared faster than his output. In short, our watchmaker discovered the dis-economy of size, went bankrupt, and got beheaded, which, of course, closes the tale of the watchmaker.

For all those who still comprehend fairy tales (Harvard calls them case studies), essentially all has been told with regard to the two powers of subdivision of labor: (1) the gain through learning, and (2) the loss through management overhead. However, for those who abhor fairy tales, the following analysis may be illuminating. Please bear with me; the subject is not difficult, but slightly complicated.

An Analytical Sketch

In the acquisition of industrial products or systems of any nature, the buyer is always faced with the source selection process or the decision of where to buy. Price, quality, and delivery time are a few of the many criteria used in this process or decision. Most, if not all, of those criteria can be classed or summarized as aspects of compatibility between the product and the producer. For example, some producers may be best suited to build individual units or small series of a product, while others may excel in large series production. Labor and capital intensity, leverage in production and plant layout are a few of the attributes that form compatibility. As an illustration, every superintendent of a large shipping line knows exactly, and without going to a bidding process, at what shipyard he will get the best price for a particular type and size of a repair and overhaul job. Intuitively, this pragmatic knowledge implies that there "might be" an optimal

size of an organization for a particular job. Unfortunately, the "might be" has been ignored in industrial analyses and the idea that "bigger is better" (in the terminology of the economist called the "economy of size") has been accepted without critique. It has escaped analytical attention that the concept of economy of size has only conditional validity: It is valid for "communication-poor" operations, but not for "communication-rich" operations.

Typically, communication-poor operations are mass production operations, where each workstation communicates only with the foregoing and the follow-on workstation. Communication-rich operations are construction operations and intellectual operations like schools or research groups, where each worker or workstation must communicate with many other workstations.

The existence of workstations is postulated as synonymous with the concept of subdivision of labor, and the *gain* thereof can be expressed in terms of learning theory. The existence of the need to communicate among workstations is postulated as synonymous to the concept of management, and the costs thereof are the *penalties*; they can be expressed in terms of the structure of a hierarchy. Whenever the trends of penalties are opposing the trends of the gains, an optimum must exist, and, therefore, the concept of optimality, in the case at hand the "concept of optimality of size," is established. Figure 1 illustrates this in a generic way.

A discussion of the concept of optimal size based on the concept of subdivision of labor and a graphic portrayal of the underlying problems are presented in Part I of this paper. In Part II, the wide implication of the analyses will be discussed, and attention will be given to the implications on the acquisition process.

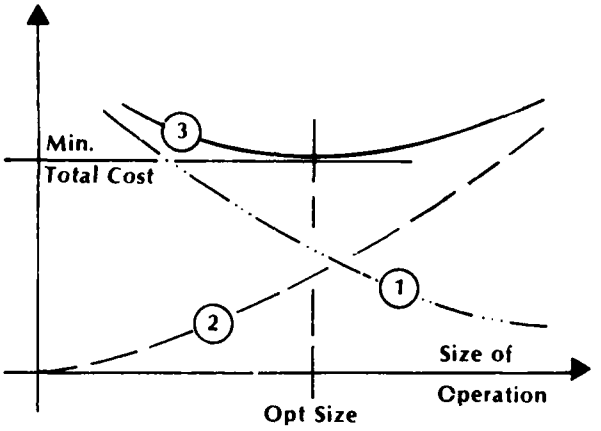
PART I: THE CONCEPT OF SUBDIVISION

We will start with some definitions, explain each building block of the concept, and finally will summarize the building blocks into a single picture in the form of a nomogram. This nomogram will then be used to explore different industrial behavior patterns.

DEFINITIONS

In the following analyses and discussions, many terms are used like "learning," "construction," "production," and "manufacturing module." Some of these terms will be new to the reader; others are not uniquely defined in the literature. Therefore, it seems practical to give definitions for some of those terms as used in this paper.

FIGURE 1
The Concept of Optimal Size



NOTES:
Curve 1—Decreasing unit manufacturing cost with increasing size of operation.

Curve 2—Increasing unit management cost with increasing size of operation.

Curve 3—Manufacturing cost plus management cost results in minimum total cost and optimum size.

Construction: Construction is considered an abstract concept, describing the making of "one of one" unique unit.[1]

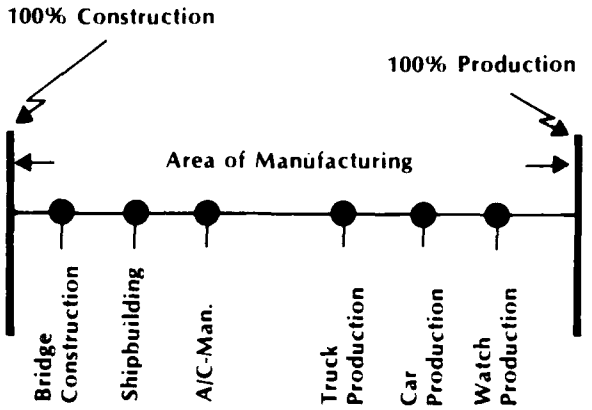
Production: Production is considered an abstract concept, describing the making of an infinite number of identical units.[2]

Manufacturing: The two abstract concepts of construction and production are the borderlines for the area of manufacturing, the area of reality with exclusion of

1. Franz A. P. Frisch, "Production and Construction," 5th Annual DOD Procurement Research Conference 1976 (published in abbreviated form); "Production and Construction in Shipbuilding and Other Industries," 12th Annual Symposium—The Association of Senior Engineers—of NAVSEA, 1975; "Lecture Notes on Industrial Economy," Virginia Polytechnic Institute and State University, 1977.
2. *Ibid.*

the boundaries. However, each manufacturing process will *tend* either toward production or construction as illustrated in Figure 2, showing that each manufacturing process is an ill-defined mixture of construction and production.[3]

FIGURE 2
Area of Manufacturing



Manufacturing Module: The manufacturing module describes the minimum amount of resources of talents, facilities, and tools which *must* exist (regardless of utilization) in order to be able to manufacture a specific product. For example, in the watchmaker's tale, you must have 256 morons with specialized tools where everyone can make one simple piece of the watch in order to have one complete watch. Of course, those 256 morons with facilities and tools are only fully employed if they are making 1,000 watches per year. Regardless of their full employment, the 256 morons with their tools are the manufacturing module of our master watchmaker.

Learning: If some tasks in industry are performed over and over again, they will be done better and better or faster and faster. This phenomenon has been observed in aircraft construction,[4] ship construction,[5] and other industries. According to industrial theory, learning never stops; according to the observations in experimental psychology, it reaches a plateau. The difference between these

3. *Ibid.*
4. Miguel Angel Reguero, "An Economic Study of the Military Airframe Industry," Department of the Air Force, 1957.
5. Gerald J. Fischer, "A Statistical Summary of Shipbuilding Under the U.S. Maritime Commission During World War II," *Historical Reports of War Administration*, U.S. Maritime Commission, No. 2, 1949.

two opinions is embedded in the fact that industrial learning includes not only the labor-learning, but also the outcome of management efforts or management learning, and the impacts of investment called capital learning. Unfortunately, those differentiations are rarely made[6] and most often all three impacts are inseparably intermixed. For orientation, I offer in Table I a breakdown of those three learning aspects. The table shows, for example, that the participation of labor learning amounts to only 5 percent of the total learning effect in production, while it amounts to 15 percent in construction.

TABLE I
Learning Participation

PARTICIPATION OF	IN ACTIVITIES TENDING HEAVILY TOWARD CONSTRUCTION	PRODUCTION
(1) Labor Learning	15%	5%
(2) Management Learning	55%	15%
(3) Capital Learning	30%	80%
TOTAL "SIMULATED LEARNING"	100%	100%

Simulated Learning: Investment improves the output per worker; better management improves the output per worker, and the worker learns, too. Therefore, all three effects can be expressed in the form of "learning" although really only one part is true learning. Whenever all three learning effects are considered together, the term "simulated learning" is used.

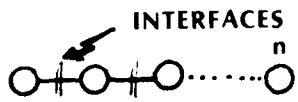
Communication-poor Operations: If a particular task is subdivided into many specialized subtasks, then the need exists to reconstitute the whole from the parts. The need also exists to manage the interfaces between the parts in regard to function, form, and time.[7] The simplest form of an interface structure is the line structure as shown in Figure 3. We call operations with line structure of interfaces and hence $(n-1)$ interfaces "communication-poor" operations.

Communication-rich Operations: Communication-rich operations are those where many nodes have to interface with each other, thereby forming a net-structure as shown in Figure 4. More rigorously expressed, communication-rich

6. W. J. Abernathy and K. Wayne, "Limits of the Learning Curve," *Harvard Business Review*, September-October 1974.

7. Christopher Alexander, "Notes on Synthesis of Form," Harvard University Press, 1964; and Franz A.P Frisch, "The Understanding of Communication Systems," Selected Notes, 1972/73 Research Report for NTDS Office, NAVSEC.

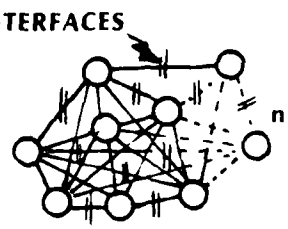
FIGURE 3
Line Structure



n nodes

(n-1) Interfaces

FIGURE 4
Net Structure



n nodes

$\frac{(n-1)n}{2}$ Interfaces

operations are all those operations where the communication needs cannot be satisfied with a line structure. The maximum possible interfaces are given when all nodes have to interface.

Valid Interfaces: The valid interfaces are those parts of the maximum possible interfaces which are actively used. Therefore, they can be expressed as a percentage of the maximum possible interfaces. However, they can never be numerically less than the minimum as given by the interfaces in the line structure.

THE BUILDING BLOCKS

The building blocks of the problem at hand are as follows:
—The interaction of subdivision of labor with learning;
—The valid interfaces and communication;
—The form of the management hierarchy.

First, we will discuss each building block separately and thereafter combine the building blocks into one single nomogram. This, in turn, will provide us with a working tool for further analysis.

Subdivision of Labor and Learning. Let's assume it takes one *unit-time* for one man to produce a certain product. Now let's subdivide his activity into two workers; each will need ½ unit-time for his part, and, therefore, will repeat his work twice in the unit-time. The second time, however, each will do it more efficiently than the first time; if each does it the second time in 90 percent of the first time, we say he progresses with a learning rate of 0.9. If we subdivide the task into four instead of two subtasks, the worker will repeat his ¼-task four times in the unit-time and will learn even more, and will take only $0.9 \times 0.9 = 0.9^2 = 0.81$ unit times. Or, differently expressed, the worker who makes four times ¼ of the job will have time to spare or be able to make more than four pieces in the unit time. Industrial observations show that each doubling of repetition results in a unit reduction by the learning factor as illustrated in Table II.

Depending upon the subdivision of labor, or the subdivision of the task, each worker making $1/n$ of the whole will repeat his job n times in the unit time, and will, hence, reach a certain learning level. This learning level, or plateau, may be the steady-state work performance for the future. Therefore, the worker's output will be the unit-time divided by the time achieved at the last unit where he reaches the learning plateau. Should future learning occur, we are able to express this with a higher learning rate; let's say with 0.85 instead of 0.9 in the subsequent unit-times.

Now we can extend Table II and show the worker's output at the learning plateau in Table III. Table III shows, for example, that a subdivision of a task into eight parts leads to the making of only 1/8 by each worker and also an eight times repetition during the unit-time. With an assumed learning rate of 0.9, this leads to

TABLE II
Learning with Factor 0.9

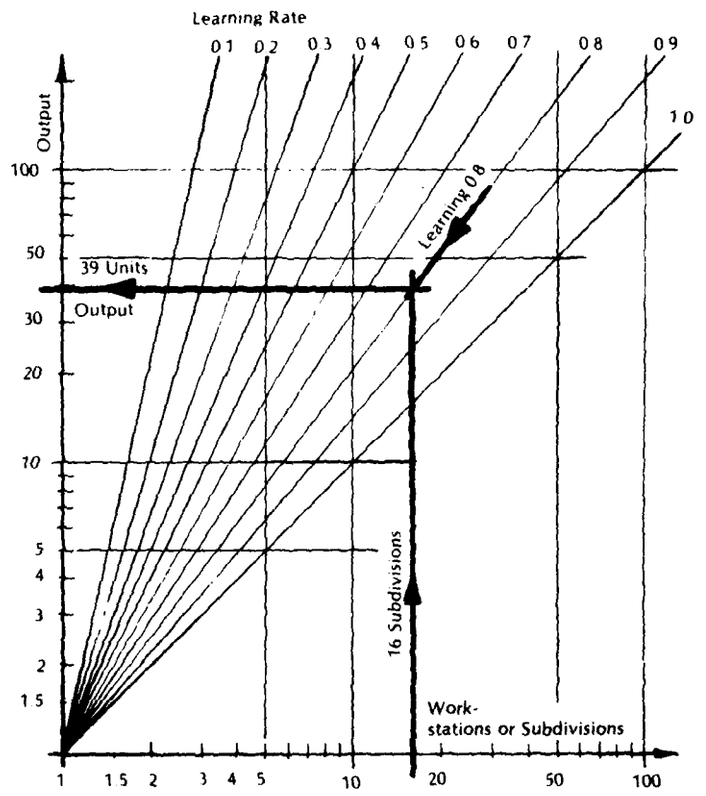
MULTIPLIER TO UNIT	UNIT NO.	LEARNING FACTOR	UNIT TIMES (UT) NEEDED FOR
	1	$0.9^0 = 1$	The 1st piece...1 UT
1x2 =	2	$0.9^1 = 0.9$	The 2nd piece...0.9 UT
2x2 =	4	$0.9^2 = 0.81$	The 4th piece...0.81 UT
4x2 =	8	$0.9^3 = 0.729$	The 8th piece...0.729 UT
8x2 =	16	$0.9^4 = 0.656$	The 16th piece...0.656 UT

TABLE III
Learning Gain

NUMBER OF SUBDIVISION	SIZE OF INDIVIDUAL TASK	REPETITION OF TASK IN UNIT TIME	UNIT LEARNING FACTOR FOR THE LAST REPETITION	PIECES PRODUCED IN UNIT TIME AT PLATEAU	GAIN
1	1	1x	1	1:1 = 1	0
2	1/2	2x	0.9	2:0.9 = 2.2	0.2
4	1/4	4x	0.81	4:0.81 = 4.9	0.9
8	1/8	8x	0.729	8:0.729 = 11.0	3.0
16	1/16	16x	0.656	16:0.656 = 24.0	8.0
.	.	.	.	.	.
.	.	.	.	.	.
etc.	etc.	etc.	etc.	etc.	etc.

a learning factor of 0.729 for the eighth piece. This shall be his learning plateau—with which he can produce in the following unit times almost 11.0 pieces, with a gain of three pieces produced in the unit-time. This number game can be extended *ad infinitum*, hence it behaves logarithmically.[6] We can plot the behavior in straight lines in log-log form in Figure 5A. But since log-log presentations are a visual distortion of reality, we will replot, for the purpose of clarity,

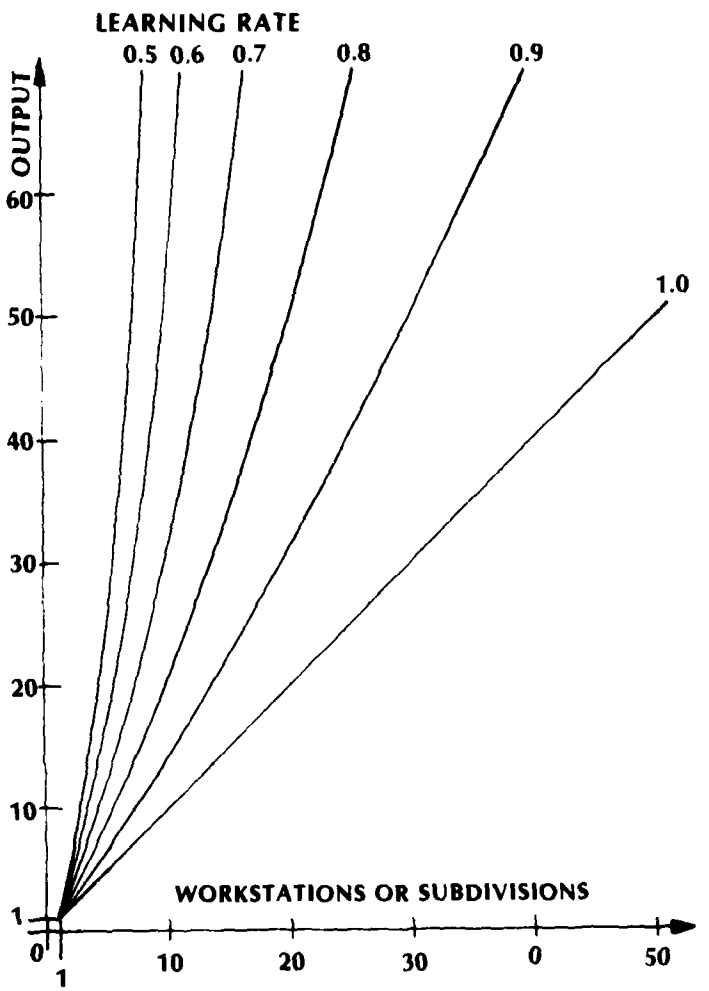
FIGURE 5A
Output with Learning (Log-Log Form)



8. R. A. Harris *et al.*, "Alpha and Omega and the Experience Curve," U.S. Army Logistics Management Center, Fort Lee, Va.

the behavior in Figure 5B in linear-linear form. The subdivision of labor is called out in Figures 5A and 5B as workstations.

FIGURE 5B
Output with Learning (Linear Form)



Valid Interfaces and Communication. If a particular work is subdivided into many subtasks, one purpose of management will be (a) the supervision of the individual tasks, and (b) the management of the interfaces among the subtasks. Both the supervision, and especially the management of the interfaces, will help to reconstitute the whole out of the subtasks.

The activities of supervising and managing the interfaces have to occur at the same time, and, therefore, we will combine both under the single term of "communication." It can also be argued that the management of the interfaces includes tacitly the supervision of the individual tasks, and meaning only the interfaces deserve to be counted. We will proceed on this assumption and will identify the management activities and communication activities with the number of interfaces.

The number of communication activities will depend upon the number of nodes (or workstations) and upon the structure of the organization. The minimum number of communication activities is associated with the line structure, and the maximum with the net structure. (See Figures 3 and 4.) Thus, the number of communication activities of all intermediate structures[9] must be between those limits, and can be expressed in percent of the maximum number of communication activities or interfaces.

The fully developed net structure, where all nodes must communicate on a continuous basis with each other, may only be found in intellectual activities such as research, where the activities are mostly restricted to small groups of intensively interacting researchers. The plain linear structure, on the other hand, will only be found in smaller production line operations or operations organized in a rigid linear flow. These two border cases are rather clear-cut abstractions. But move from the abstraction to the real world and the whole thing looks quite different.[10] Although the possible number of communications or interfaces in a complete net is $(n-1)n/2$ or approximately $n^2/2$, not all of those will be valid and only the *de facto* communication links must be considered. Differently expressed, the valid interfaces must be managed.

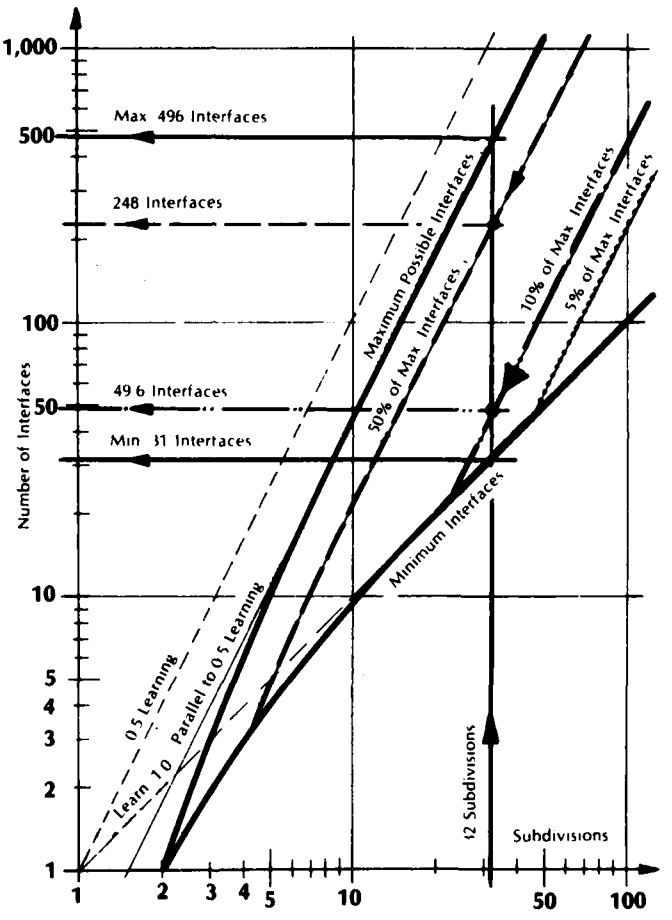
The search for the valid interfaces, while seemingly simple enough, may prove most difficult. Therefore, in order to show the total validity range, I have plotted in Figures 6A and 6B the line for 50 percent, 10 percent, and 5 percent validity between the limits of the 100 percent validity, which is identical to the maximum number of interfaces and the minimum line. The minimum number of interfaces or communications is shown as percentage of the maximum number in Figure 7.

The problem of the validity of interface is acknowledged, however, at this moment it is not further pursued because it has quantitative but not substantive

9. Harold J. Leavitt, "Some Effects of Certain Communication Patterns on Group Performance," *The Journal of Abnormal and Social Psychology*, 1951.

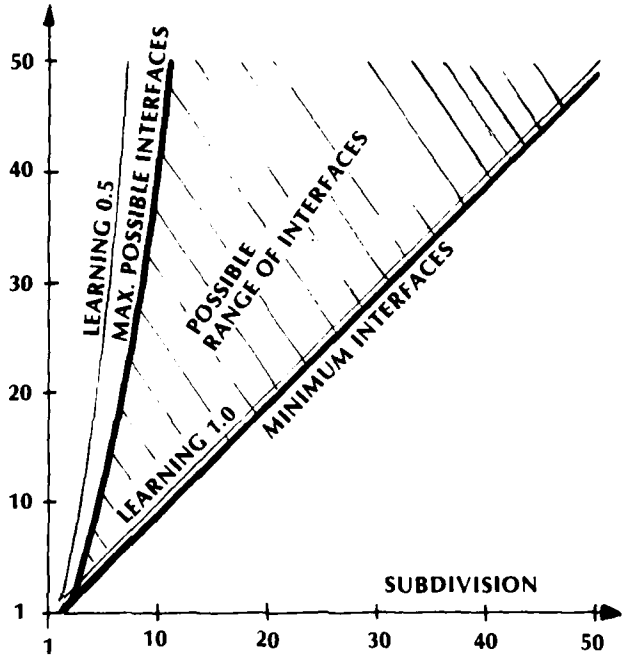
10. Carl von Clausewitz, *On War*, Translation: Princeton University Press, 1976.

FIGURE 6A
Range of Interfaces (Log-Log Form)



relationship to the present topic. It will be shown that the amount of the valid percentage of interfaces shifts the numerical result, but does not and cannot change the essence of the results.

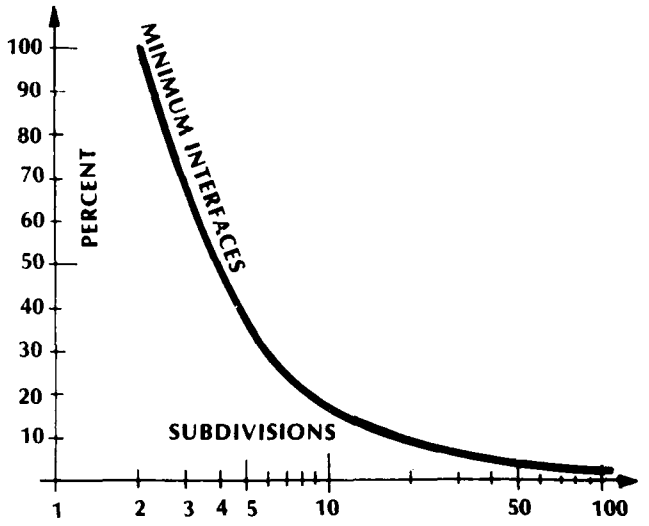
FIGURE 6B
Range of Interfaces (Linear Form)



Form of Management Hierarchy. Let's start with the statement that management has to control the valid interfaces in an organization. Then one may ask immediately: How many "managers" are needed in order to control or to manage *n* interfaces? Is one manager needed for three interfaces, for seven, for twenty, etc.? Again, no firm and magic answer exists because it depends upon the complexity of the interfaces, the permissable delay in decision, the risks of non-decision, and many other factors such as the perception of the manager,[11] the uncertainties

11. George A. Miller, "The Magic Number Seven, Problems of Perception," *The Psychological Series*, Harvard, Vol. 63, No. 2, 1956.

FIGURE 7
Minimum Number of Interfaces Expressed In Percent of Maximum Possible Interfaces

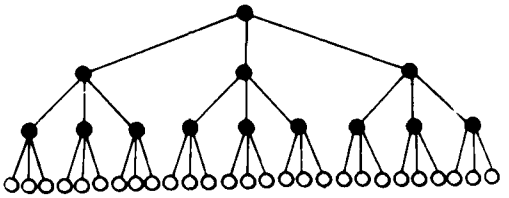


embedded in the information, and so forth. Management literature deals extensively with this problem. Presently, it is only of importance to establish the relationship between the management structure and the number of management positions in relation to the valid interfaces. In order to do this, we line up the valid interfaces at the lowest level of a hierarchy, sketch above the selected management hierarchy, and count the nodes. This procedure is sketched in Figure 8 with the results plotted in Figure 9A in log-linear form, and in Figure 9B in linear-linear form.

COMBINATION OF BUILDING BLOCKS

The building blocks have been shown individually in Figures 5, 6, and 9. Now we combine them into a single *working nomogram* as shown in Figure 10 (together with a guide to reading this nomogram). For practical reasons, the working nomogram had to be plotted in log-log form and log-linear form. However, the user shall not forget the deceptive appearance of those nonlinear plots.

FIGURE 8
Structure and Management Nodes



○ = INTERFACES
● = MANAGEMENT NODES IN 1-3 HIERARCHY

The working nomogram is subdivided into four fields: Field 1 considers the learning effect (see also Figure 5A); Field 2 considers the interfaces (see also Figure 6A); Field 3 represents the total hierarchical structure (see also Figure 8); and Field 4 considers the management aspects (see also Figure 9A).

The working nomogram will be used to discuss selected problems that can be reduced to the interplay of (1) the gains because of the subdivision of labor with its resulting learning effect, and (2) the losses because of the need to manage the interfaces resulting from the subdivision of labor. In order to get better insight into the behavior of the problem we will first fold Field 2 of the working nomogram into Field 1 as shown in Figure 11.

The combination of learning and interfaces in Figure 11 shows:

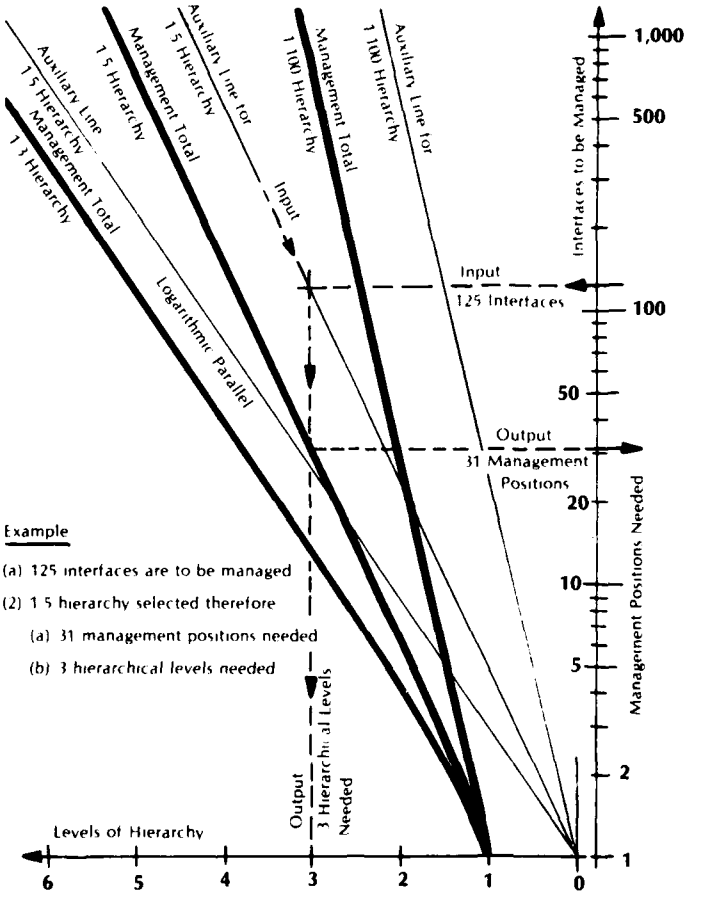
—The minimum interface line approaches asymptotically the learning line for factor 1.0 (and for practical purposes can be considered identical to the learning line of 1.0 for each subdivision into 25 or more stations).

—The maximum interface line approaches asymptotically a log-log parallel line to the learning line for factor 0.5 (for practical purposes can be considered as identical to the asymptote for each subdivision into 25 or more stations).

—From the first observation it follows with necessity that all validity lines cannot drop below the minimum interface line and all learning rates above 0.5 (such as a learning rate of 0.3, 0.2, etc.) cannot be crossed by an interface line.

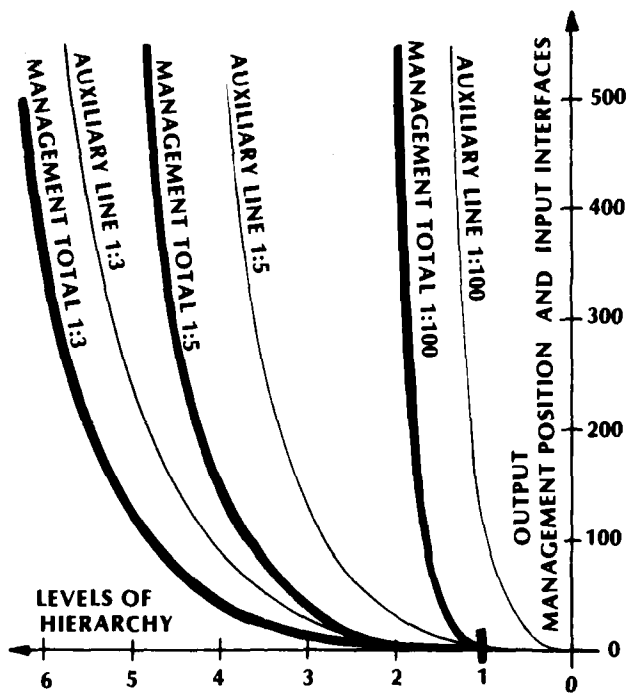
—Therefore, any operation with a simulated learning below 0.5 must have a *distinct optimum*, while each operation with a simulated learning of 0.5 or better can grow unlimited with continuous gain from the economy of size.

FIGURE 9A
Valid Interfaces and Management Nodes (Log-Linear Form)



The four above observations are illustrated by Points A and B in Figure 11. For example, the line for the 0.8 learning rate will cross the line for the 10 percent validity of interfaces at Point A and the line for the 1 percent validity of interface

FIGURE 9B
Valid Interfaces and Management Nodes (Linear Form)



at Point B. Hence, it is not a question of *if* but only *when* a specific learning rate line below 0.5 will cross a specific validity line of interfaces.

Figure 11 shows also a subdivision of the entire area of manufacturing, or the production function composed of labor and interfaces into three distinct zones: Zone I is the area where the economy of size has unlimited validity; Zone II is the area where an optimum size and absolute maximum size *must* exist; Zone III shows those combinations of interfaces and labor which are not valid. Note that we are talking about interfaces; the translation of interfaces into management position is not shown in Figure 11. However, it can be easily achieved with the working nomogram.

FIGURE 10
The Working Nomogram

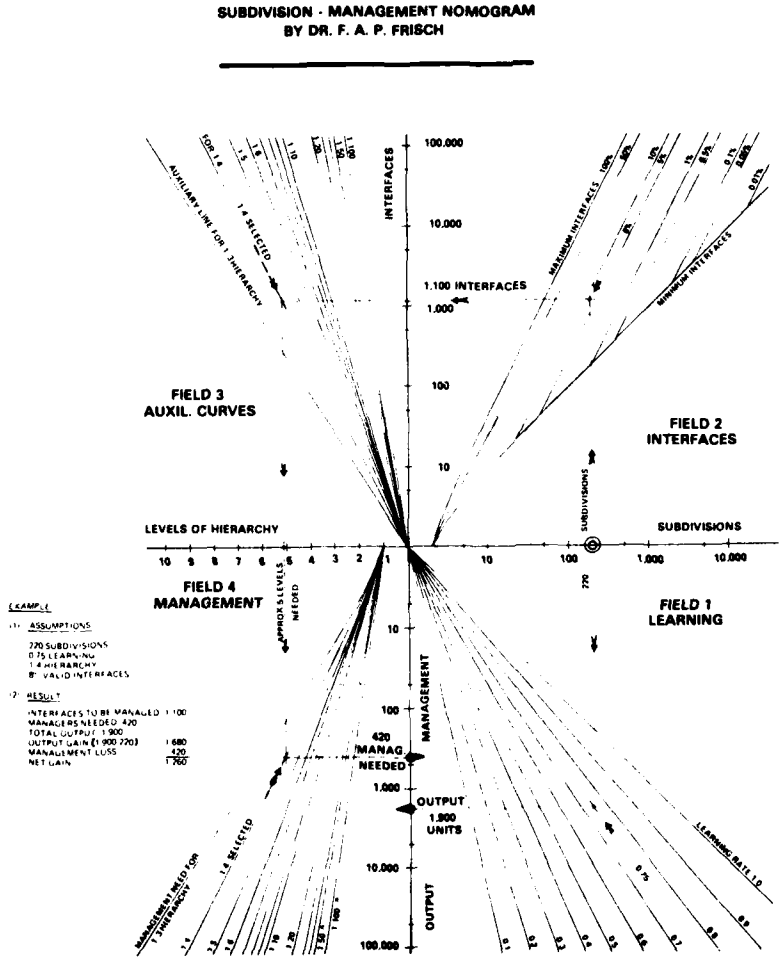
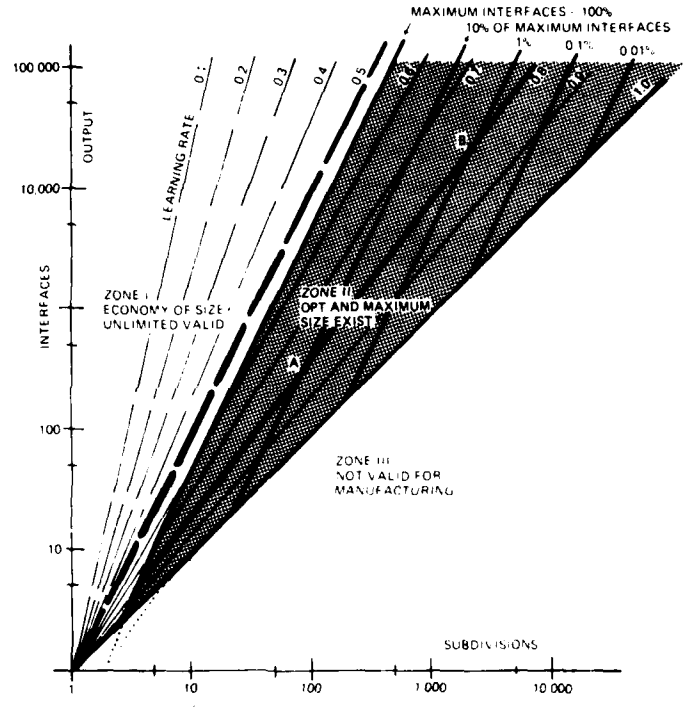


FIGURE 11
Combination of Valid Interfaces and Learning



GENERIC BEHAVIOR

In order to get additional insight into the interaction of the elements, two generic cases will be explored. Both cases are related to the growth of an enterprise in manufacturing, and each case portrays one extreme solution: first, the growth along a fixed learning rate; second, the growth along a fixed subdivision. These cases are blocking out reality, or, actually, they better set the boundary for reality which consists of an infinite combinatorial variation of the two extreme solutions. If the behavior for the extreme or pure cases is known, all mixtures thereof can be easily deducted.

Growth With Fixed Learning. We assume that the output plateau of a manufacturing process will be reached along a fixed (let's say an 0.85) learning rate. This means the specialization of the work force will continuously increase, and the output will grow exponentially. In addition, we make the naive and optimistic assumption that the range of the valid interfaces will be held constant at the 5-percent level. With this particular assumption (see Figure 12) we are entering the working nomogram and read the gains and losses for a series of subdivisions in order to calculate the net gain or the net loss. The values as taken from the nomogram and the consequent calculations are shown in Table IV. The results of the calculations are replotted in Figure 12 assuming a 1:7 hierarchy.

FIGURE 12
Growth with Fixed Learning and Fixed Interfaces

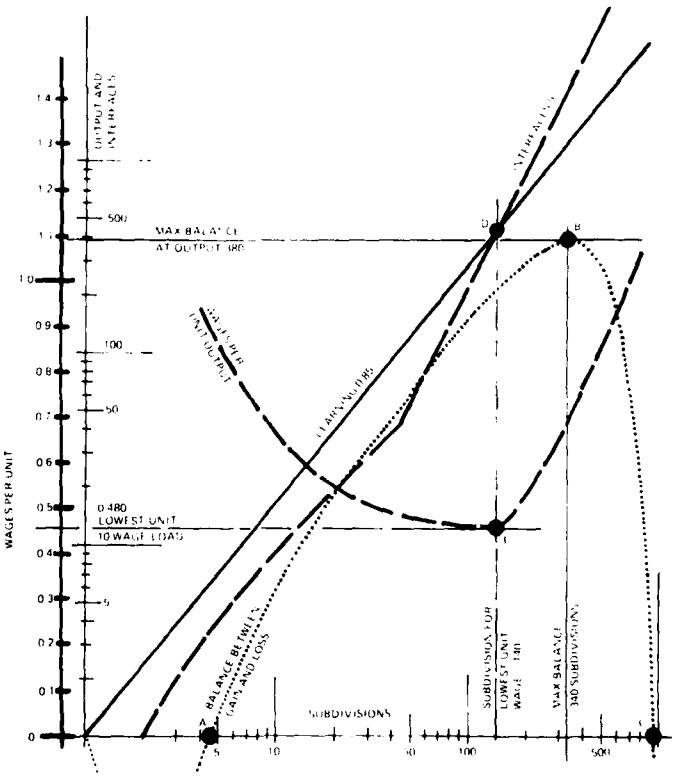


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TABLE IV

Calculation of Optimal Behavior (Learning 0.85)

1	2	3	4	5	6	7	8	9	10
SUBDIVISIONS	TOTAL OUTPUT	GAIN: OUTPUT	INTERFACES TO BE MANAGED IF 5% VALID	LEVELS OF HIERARCHY NEEDED	MANAGERS NODES	LOSS: COUNTED NODES WITH WAGE FACTOR 1.2	BALANCE COL 3 + COL 7	TOTAL PAYMENT NODES	PAYMENT PER UNIT OUTPUT (W/O MATERIAL)
1	1	0	0	0	0	0	0	1.	1.
2	2.35	0.35	0.05	0	1	1.2	-0.85	3.2	1.29
4	5.54	1.54	0.03	0.7	1	1.2	+0.34	5.2	0.94
8	13.0	5.0	1.04	1.1	1	1.2	+3.8	9.2	0.71
16	30.6	14.6	6.00	1.4	1.1	1.3	+13.3	17.3	0.57
32	72.1	40.1	24.8	1.9	5	6.0	+34.1	38.0	0.53
64	170	106	100.8	2.4	16	19.2	+86.8	83.2	0.489
128	399	271	406.4	3.1	65	78.0	+193	196	0.491
256	939	683	1,632	3.8	265	318.0	+365	574	0.61
512	2,211	1,699	6,540	4.5	1,200	1,440	+259	1,952	0.88
1024	5,201	4,177	26,189	5.3	4,100	4,920	-743	5,984	1.15
2048	12,238	10,190	104,807	5.8	15,200	18,240	-8,050	20,288	1.66

NOTES TO TABLE IV:

Column 1 indicates the subdivisions of the total task - representing workers or workstations.
Column 2 shows the output achieved at a 0.85 learning rate level.
Column 3 shows the gain in output because of subdivision of labor and 0.85 learning plateau.
Column 4 shows the total interfaces to be managed with 5% validity of all possible interfaces.
Column 5 shows the levels of the hierarchy. The decimals indicate incomplete hierarchial structures).
Column 6 shows the management nodes needed to manage the valid interfaces of column 4.
Column 7 makes an adjustment for the average wage ratio of the workers versus managers. A factor of 1.2 is assumed and hence column 7 shows the equivalent nodes for management which represent the loss forces.
Column 8 combines the gains (column 3) with the losses (column 7) and shows the NET-gain of the operation.
Column 9 adds the workers (column 1) with the management nodes (column 7), representing the total work force or payroll equivalent.
Column 10 finally, divides the total work force (column 9) by the total output (column 2) and hence depicts the work force allocation by unit output.

Five distinct points are highlighted in Figure 12. First, Point A shows the minimum size for the particular operation. Below this size the gain through subdivision cannot support a management function. (In order to "see" the negative values of Table IV, a replot of Figure 12 into linear-linear form would be necessary.) Second, Point B has the highest balance between gain because of learning and losses because of management. Third, Point C indicates where gains through subdivision cannot support anymore the management losses needed to control the increasing interfaces. Finally, Point D, the intersection between the learning line and the interface line, is at the same station of subdivision as Point E, which has the lowest wage cost per unit. (A light shift between the ordinate for Points D and E can occur if the factor between workers and management wages is not 1.0.) The identity in the ordinate for Points D and E also indicates the shift of the marginal wage load per unit from positive to negative increments.

Growth Along Constant Subdivision. The growth with fixed subdivisions is a trivial case if considered only from the interplay between gains because of subdivisions, and losses because of management: the gains, by shifting into better and better learning rates, increase productiviy on a continuous basis. However, the growth with fixed subdivisions and permanent increasing output per workstation is not trivial as soon as the capital necessary to achieve this improvement is brought into the picture.

As long as we restrict learning to "workers" only the learning plateau will be reached about at a 0.90 learning rate. If we accept that the term of learning shall also simulate the learning of the management, we may with workers and management together achieve a learning plateau about along a 0.80 learning rate. A better learning effect can only be achieved if we add capital learning as part of the simulated learning process. This means we have to buy better tools so that each worker can produce more without need to increase the management structure.

Today, we have the technology to achieve a simulated learning effect of 0.5 or better and break through the barrier below which the management losses are higher than the gain through learning. Of course, we are increasing the complexity of the individual element, and the worker may have to be a high-skilled computer operator. The system may be self-defeating for two reasons: (1) we have abandoned the original idea of replacing high-skilled workers with many low-skilled workers and returned to the need of a few even higher and differently skilled workers; (2) we introduce a new dimension into the "problem of progress," namely, the trade-off between capital cost and labor cost.

Combined Growth Pattern-Production Function. The foregoing sections describe the two extremes of growth patterns—the one along a constant learning effect, the other along a constant subdivision. These two growth patterns, of course, permit any desired combination and portray in its totality *all possible production functions* for any given good. Of course, this is a new and a much extended interpretation of what is commonly called the production function.

PART II: INTERPRETATIONS (FIVE SKETCHES)

The concept developed in Part I, and especially the working nomogram (Figure 10), permits one to play with problems related to the subdivision of labor. By "play," I mean we have a tool or a simple model with which we can test different hypotheses, opinions, and ideas of how they might behave, what influence they may have, etc. I summarize these hypotheses, opinions, and ideas under the term of interpretations, and a few of those shall be sketched in the hope of generating response and constructive critique. At this time, I suggest considering the interpretations as conjectures and not as well-researched findings. Although the four following interpretations will be consistent in logic, they are definitely not coherent in their loose presentation; they are just illustrations.

HISTORICAL TRENDS

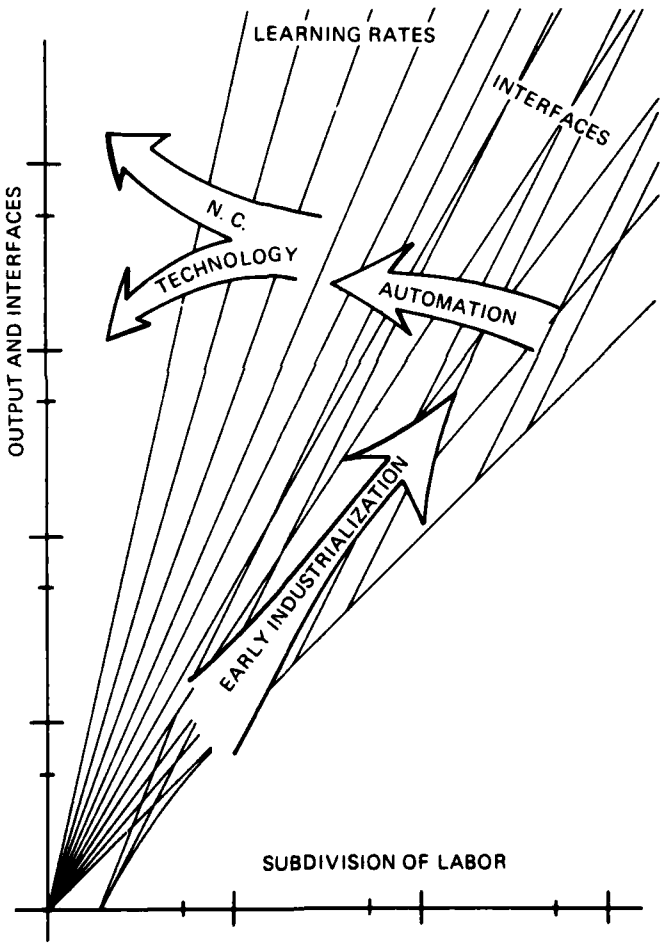
I claim it is possible to depict in the working nomogram in coarse macro form the historical trend of industrial development. The three phases, shown in Figure 13, would be (1) the early industrial trend with the enlargement of factories based upon the subdivision of labor; (2) the mature trend, based upon the introduction of automation and highly structured mass production; and (3) the just-starting post-industrial trend, based on the introduction of mini-computers and numerical-controlled manufacturing technology. The graph (Figure 13) only gains full meaning if placed in context with the market history of growth. Then we may be able to understand and place the early migration of workers into the industry; we may explain full employment while productivity skyrocketed; and we may highlight problems of employment in a stagnant economy. We may also explain the non-inventiveness of certain cultures, faced with a constant resource base, a stable agricultural output, and a stable population with "cultural" dictated standardized consumption.[12]

THE TOTAL PICTURE

It is easily observable how the subdivision of labor has continuously increased the manufacturing module and, in time, has lead to increasing concentration into manufacturing centers. This concentration was possible only because of increased transportation capabilities, which have given the opportunity to have manufacturing centers remote from material sources, and from the market. Or, the other way around, manufacturing places can be shifted into the area of the least expensive indigenous labor forces, provided the indigenous training level is suitable to the subdivision as desirable for a given or anticipated output. For clarity, the relationships called out in the foregoing sentence are sketched in Figure 14 and broken into four distinct triangular relations.

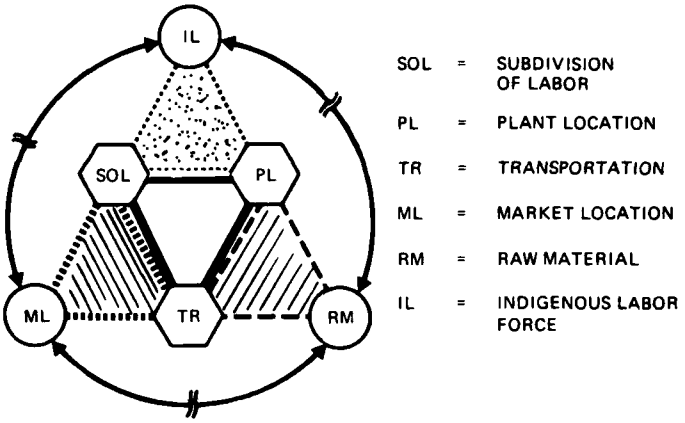
12. Karl Polanyi, "Primitive, Archaic and Modern Economies" (Essays of K. Polanyi in *Economic Anthropology*), Beacon Press, edited by Dalton, 1971.

FIGURE 13
Historical Trends



The corner elements in Figure 14 are connected by broken circles, indicating a possible, but not a necessary, connection between the indigenous work

FIGURE 14
Toward the Total Picture



force, the market location, and the material source. Figure 14 can be used to place into focus discussions about labor migration, industrial migration to foreign locations, and similar problems. But, and this seems to be the crucial point, none of those problems can be discussed without accounting for the technological properties embedded in the subdivision of labor, the manufacturer's concentration (and location) due to technology, and the interconnecting transport technology. I would like to go one step further and say that *the technology is in the driver's seat; economy, social structure, trade, and even culture may be responding adaptations.*

COMPATIBILITY BETWEEN MILITARY AND COMMERCIAL INDUSTRY

For the moment (only as a conjecture) it appears as if the incompatibility between military industry and commercial industry can be supported on logical ground, provided we are willing to take some futuristic viewpoint into account. In the future, military goals and social goals may polarize and move in opposite directions. The commercial industry may move toward a market stabilization under resource pressure and, simultaneously, toward the social function of tailoring tasks toward the control of unemployment. The military industry, on the other hand, may have to move under fiscal constraints toward a contraction in manpower with simultaneous increased demand for better weapons, or in economic terms with the need to satisfy an expanding market. This apparent contradiction of "more with less" can be solved through modern computerized

numerical-controlled technology, provided the capital will be available to introduce this technology on a large scale. For the commercial sector of the industry, this alternative may be counterproductive because of the worker's double function as producer, and as consumer of mass-produced items. It may be that low-technology military acquisition will shift to the advantageous buy-commercial concept, while the high-technology military acquisitions may point in the direction of a captive military industry and, conceptually, toward the traditional, but abandoned, arsenal-concept.

THE ACQUISITION MANAGER'S DILEMMA

If your neighbor beats his wife, what can you do? Legally, you can do absolutely nothing, as long as she does not ask for help. All you can do as a compassionate man is to persuade your neighbor that it is not nice to beat his wife every day. This is the equivalent to the acquisition manager's dilemma: Mostly, he can do nothing within his regulatory constraints. He may be aware that small can be efficient, but the small company may not be able to document financial responsibility for a large contract. The acquisition manager may be aware of opportunities offered by computerized manufacturing technology, but he cannot force the contractor to use such technology. All he can do is to persuade the contractor into a competitive mode, to use the technology for a military production advantageous investment; that is, providing that at least one of many contractors sees this as advantageous to himself, and does not prefer the production leverage based on labor intensity. This dilemma may be less pronounced with large prime contractors, especially when considered in context with the maintenance and protection of an industrial base for national emergency.

LIMITED KNOWLEDGE AND RESEARCH

It may be interesting to find out that a learning rate of 0.5 is log-log parallel to the maximum curve of possible interfaces. It may also be interesting to be informed that the intersection of the valid interface line with the learning rate for level performance represents the point where marginal productivity of labor, plus management, shifts from increasing to decreasing increments.

But what good is this knowledge? What can we do with it? Is it an intellectual exercise in futility, or has it practical value? The answer to those questions is disappointing because as soon as we try to "work" with the concept, we are made painfully aware of how miniscule is our knowledge about fundamentals. So, for example, I tried in vain to find information when 10 percent or 1 percent or 0.1 percent of all possible interfaces are valid interfaces. Of course, we can use the working nomogram and start the analyses with existing structures and reconstruct the valid interface value in rough approximation. But we do not have sufficient knowledge to work from the process toward the management structure.

It may well be that the recognition of how little we know may be the most valuable contribution of this paper. Also, the logic developed may help to ask the right question for future research. In particular, I envision research along the lines of the Woodward Study of 1958[13] which is, to my knowledge, the only study ever made which attempts to research the management structure in relation to the product type. The reason for the reluctance to search along those lines may be the recognized inability to "solve" those problems with exactitude or with formalistic mathematical elegance. This, however, is insufficient reason to ignore those problems, and I hope this paper may initiate some new research into the area of industrial behavior in response to the existing technology.

As first order of priority, I suggest starting with research about the connections between (1) manufacturing technology or the process, (2) the product, and (3) the market size. It may be that for certain products a monopoly position is desirable, while for other products multiple suppliers with fierce competition are appropriate. We may be able to justify for certain products vertical integration (from the oil well to the gas station), or horizontal integration (cars, batteries, and all accessories), or to justify the conglomerate structure (financial-related but functionally unrelated companies). Such knowledge may have great value for the buyer and the formulation of political directives.

An outgrowth of such research may be that we are able to redefine productivity and pinpoint the location for moral decisions in the economy,[14] based on knowledge rather than on superstition. We may learn the plurality of the necessary judgments and find out that neither smallness nor largeness constitutes, *a priori*, a virtue or a sin.

Epilogue

The leitmotiv or the continuous threat going through the paper is my conviction that the tools (or the technology) are the driving force in our society, much more so than political concepts or ideals. We have built our own technological environment and we are captivated by it. We sit in our own mousetrap: Whether we consider this good, bad, or indifferent, the fact remains. Our technology has formed tremendous manufacturing modules; for example, either we tool-up to build 100,000 cars of one type (or whatever the number may be), or we cannot build them at all. If we sell less we can stop the assembly line for days or weeks, but we cannot produce at a speed different than that which the production technology dictates. Technology in distribution and manufacturing permitted us

13. J. Woodward, "Management and Technology," HMSO-1958, reprinted in *Organization Theory, Management Reading*, edited by D.S. Pugh, Penguin, 1971.

14. Philip J. Wogaman, *The Great Economic Debate—An Ethical Analysis*. The Westminster Press, 1977.

to ignore the infrastructure of an economy for the sake of efficiency. Our production work force at the end of World War II was about 55 percent of the total work force. It is today less than 20 percent of the total work force. In the year 2000, it will be about four to ten percent of the total work force.[15] Try to imagine that less than 10 percent of the work force will be able to produce everything (including food) that the other 90 percent will consume and export. Must this not lead to a new definition of the meaning of productivity, of work, of learning and education? Will this not be a reversed slave economy where few are working for many while, in the not too distant past, many worked for a few? How many consumers can we lose in a nuclear-induced attrition before our manufacturing modules are irrelevant for the remaining population? What is the appropriate technology[16] under resource pressure?

I know that these are uncomfortable questions. But how can we approach them as long as we do not understand the behavior of our technology? We have not generalized manufacturing theory[17] that helps us to understand these problems and to deal with them in an unemotional fashion.

I am optimistic and see no need to go from "know-how to nowhere,"[18] but the prerequisite is to recognize the forces of our self-made environment and to contribute to this recognition. ‖

Author's Note: This paper will be part of my forthcoming book on general manufacturing theory.

15. Daniel Bell, *The Coming of Post-Industrial Society*, Basic Books, Harper, 1976.
16. E. F. Shumacher, *Small Is Beautiful—Economics as If People Mattered*, Harper and Row, 1973.
17. Bernard Chern, "Production Research and Technology," RANN-GRANTEE's Conference on Production Research and Industrial Automation, University of Rochester, 1975.
18. Elting E. Morison, *From Know-How to Nowhere, the Development of American Technology*, Basic Books, 1974.

103 Acquisition Review: A Help or a Hindrance?

Lieutenant Commander Phillip I. Harvey, USN

The Chief of Naval Material established the Acquisition Review Board (ARB) in June 1977. Composed of the Deputy Chief of Naval Material for Acquisition, the Deputy Chief of Naval Material for Logistics and the Director of Resources Management, the board was established to provide corporate oversight of the entire acquisition process for major weapon systems under development by the Navy. In addition to corporate oversight, the board provides a certification of the adequacy of the development process prior to the conduct of higher-level reviews such as the Chief of Naval Operations Executive Board (CEB), the Department of the Navy Systems Acquisition Review Council (DNSARC), and the Department of Defense Systems Acquisition Review Council (DSARC). While it may at first appear that the ARB was yet another arbitrarily added review in the process, it has, in fact, precluded the need for many former preliminary reviews.

Specific problems addressed by the ARB have arisen from many sectors both from within the material command as well as from without. In many instances, the individual project managers have requested a review in order to resolve issues. On other occasions, individual systems commanders or ARB members have requested that specific issues be addressed.

In addition to individual program reviews, the ARB has addressed the broader issue of the relationship between the individual programs that make up a major weapon system or a particular mission area. These reviews, termed composite reviews, have examined the interfaces between various programs to ensure that the necessary components were properly in phase with the host platform. The complexities of cost, schedule, and technical interfaces are placed in perspective to permit examination of particular component programs that may have a detrimental impact on the total weapon system.

Lessons Learned

The ARB over the preceding 18 months has reviewed more than 100 major weapon system acquisition programs. In addition to providing corporate oversight, the review minutes that document the proceeding serve as "lessons learned" for the acquisition process within the Navy. While each program reviewed has been unique in many respects, there are nonetheless many program management areas which are common and which require periodic attention. Management areas that frequently befall Navy programs include:

—Transition from R&D to production;
—Requirements definition and the allocation of resources;
—Inconsistencies between authority (DSARC) and fiscal (POM) processes;

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—Project management structure;
—Monitor and control of cost/schedule;
—External influencing factors.

TRANSITION FROM R&D TO PRODUCTION

This is the one area that most commonly creates difficulties. This is "where the rubber meets the road," the most important stage in the entire development process. This phase will determine if we are able to field an affordable weapon system. One reason this area causes problems is that professional weapon systems acquisition managers are optimistic; they are imbued with a healthy dose of the "can-do" spirit. Such an attitude is needed to accomplish the task at hand, but it must be moderated by the realities of time and money if we are to accomplish the objective. The most common problem, therefore, is our natural optimism, which tends to leave us without sufficient management reserves in the critical elements of time and dollars. While the solution is obvious, it is difficult to implement because of the increased pressure to field less costly systems more quickly. In many instances, expenditure of additional time and money at this juncture would have precluded disastrous consequences. Factors such as forced and unplanned schedule concurrency increase overall program risk. Also contributing to these difficulties are premature mass production of systems that have not been fully tested, resulting in a flurry of change proposals and creating havoc with logistic support and configuration management and hastily executed letter contracts, which have proven difficult to definitize. A question apropos to this portion of the acquisition process is, how much testing is enough? Frequently, we tend to overlook the obvious in favor of the documented policy. The net result is that common sense may not be applied, causing the program to be delayed. This is prevalent in systems using a common subsystem such as a computer, a display, or another component part that has been developed as a "standard."

The economies which accrue from commonality result from an economy of scale. Yet, in many instances we tend to over-test and to require that every detail be fully evaluated prior to granting approval for service use. This reluctance is natural, because the "waiver" and "provisional" approvals have been abused in the past. We must, however, examine each case individually and weigh the risks, costs, and benefits in as fair a manner as possible so as to arrive at the correct decision.

Another problem that relates to the question of how much testing is enough involves determining what constitutes acceptable test results. Again, we are smitten by our optimism in the reliability and performance areas.

This is not to say that we should decrease our end objectives, only that we must have a provision to develop these factors over a reasonable time span. The key to accomplishing this is the test and evaluation master plan (TEMP), which

serves as the agreement between developer and tester as to what constitutes an acceptable test. When this agreement is reached too early in the development process and is not updated to account for the inevitable changes that evolve during the development process, the results tend to be identical—difficulty in meeting the test objectives and an ensuing delay in producing the system. These delays create more problems because the break in production causes additional risk (particularly in reliability), increased cost, and a failure to achieve the objective. While there are no magic answers to these problems, we will go a long way toward preventing them if we make a conscientious attempt to examine each system individually to determine (1) how much time and money management reserve is needed, (2) how much testing is enough, and (3) what constitutes an acceptable test.

REQUIREMENTS DEFINITION

Requirements, while originating from "the other half" of the acquisition team, are in an area to which the "builder" must pay close attention. If we don't know what is to be developed, project success becomes more difficult.

There are two factors that frequently create problems. The first is our optimism once again overpowering the realities of time and assets. Even though we do our best at the onset of a program to define our needs and allocate the correct amount of resources, it is inevitable that requirements and resources change during the development process. At this point many programs falter because additional requirements are accommodated without the necessary additional time or resources.

The second factor causing difficulties concerns informal and undocumented changes to the requirements. There are finite resources available to meet our needs; therefore, any changes in these needs that necessitate the allocation of more or fewer resources will have an effect on the remaining needs. This may at first appear to be a manifestation of the planning, programming and budgeting process, but further examination shows it to be more complex because management resources are equally scarce. This has been particularly evident in programs that are taking advantage of a competitive development approach in consonance with the Office of Management and Budget Circular A-109.

These concepts, when rigorously applied, will lead to increased overall efficiency; however, it is certain that more management resources, as well as more initial financial assets, are needed to achieve efficiencies.

The solutions to these dilemmas are complex and require that (1) what is to be done be explicitly stated in terms of which needs are to be satisfied by use of the appropriate documents, i.e., MENS, DCP, NDCP, OR, etc.; (2) that these requirements be formally updated periodically to account for the changes that evolve during the development: and (3) that these requirements be satisfied

through the allocation of adequate fiscal and management resources. If this were done all of the time for all of the programs, there would be no problems. Although it may not be possible to do this for all programs at all times, it will enable us to recognize more fully what can be accomplished within constrained resources. Beyond this, it is equally important to ensure that whenever the informal lines of communication are activated between the requirements and acquisition partners, that these communications are documented to preclude problems.

INCONSISTENCIES BETWEEN DSARC AND POM

A corollary to the parallel partnership between the requirements and acquisition parts of the development process is the relationship between the program authority (DSARC) and the fiscal authority (POM). These two factions are in phase at the onset of the development process but invariably become disconnected as the program evolves. When this occurs, the results are similar if not identical in nature.

If the fiscal resources are reduced due to a reassessment of the ever-present affordability question, the requirements must be appropriately adjusted. If, on the other hand, the requirements are adjusted to take advantage of a changing threat or more efficient solutions to the need, the resources must be appropriately modified if the revised requirements are to be satisfied.

At first glance, this does not appear to be a problem, since the program authority is represented in the POM process and the fiscal authority is represented in the DSARC decision forum. However, because of the timing of the two processes, inconsistencies are frequent. Both processes involve the attention of high-level decision-makers, and the differences are often carried forward into successive development phases without reconciliation. When this happens, the differences are exacerbated and in some instances are not reconciled without a complete and total restructuring of the program. There is no simple solution to this problem; it will continue to plague our development process until the two elements become correlated in time needed and resources necessary. A project manager summarized this concern by stating: "The POM process gives me lots of money but no authority while the DSARC gives me a lot of authority but no money. It would be nice if we could get these together."

PROJECT MANAGEMENT STRUCTURE

As previously noted, there are a finite number of management personnel assets available to fill the increasing list of priority development program needs. This severe problem is common to most acquisition programs at some point in the development process.

Recognizing that the Navy must continue to use the matrix management approach to meet these needs, it must be recognized that this system is not, in and of

itself, the solution. Certain other management initiatives in the form of reorganization into functional mission project directorates were recently undertaken to alleviate burdens created by the growing number of programs.

Beyond these accepted facets lie several other concerns which must be recognized and dealt with.

The first concern is that of priorities within the matrix organization. It is a natural desire to be associated with a "glamour" program; hence, the combat systems, particularly the platforms, tend to receive the highest quantity and the best quality from supporting organizations. This is not all bad or inappropriate because these systems are more complex than those developed to be component subsystems or supporting systems. The problem arises when the supporting subsystem encounters a cost or schedule impact that will affect the parent system. When this occurs, the tendency is not to add the support needed to correct the problem but rather to determine if the subsystem can be eliminated or replaced by another subsystem. This is fine unless the faltering program is left to continue with even fewer assets than before, resulting in the ineffective use of both fiscal and management personnel resources. The apparent solution to this problem is program cancellation, but this carries with it the stigma of failure, which we are reluctant to admit.

A second factor to recognize and address is the composition of the project office staff. Currently, the national Navy weapon system acquisition project office is comprised of approximately 50 percent Navy personnel and 50 percent contract management consultants. This trend is stable but could change toward increased consultant participation if current Civil Service and military weapon system acquisition management initiatives are not successful. Contract management consultants provide a valuable and irreplaceable service, but we must retain "corporate memory" within the Navy.

A third factor affecting our ability to effectively manage acquisition programs is the diversified or fractured project management structure. This is observed in "non-glamour" programs where one segment manages the engineering development, and the matrix organization manages the production management and logistics support. This can be successful only if adequate attention is paid to the lines of communication which must exist between the various segments. These communication links take a finite amount of management attention, and in many instances unduly burden the over-committed project office staff. This can be overcome by defining the lines of authority, responsibility, and accountability for the program, and designating one individual as manager. These concerns will not be satisfied in the near future because they involve an asset that must be developed rather than purchased. In the meantime, they can be minimized through careful attention to meeting the end objective through the efficient use of the management assets available.

MONITOR AND CONTROL OF COST/SCHEDULE

The management area of cost/schedule monitor and control has received much attention, focusing on the development and implementation of control methods and systems. When these systems and methods are used effectively, it is possible to prevent the traumatic and often catastrophic results that can accompany a cost overrun or a schedule slip. All too frequently, however, these systems and methods are not employed until "after the fact" and then only to determine the reason for the problem. While this may alert us as to what to look for in the future, it does little for the present problem other than to measure and quantify the size. Programs that use the system to facilitate a better dialogue between the Navy project manager and the contractor are frequently effective in determining not only that a problem may exist at some future time, but are also able to take corrective measures to reduce the impact. Additionally, the increased dialogue facilitates a better determination of where the management attention must be applied for both the contractor and the Navy. This single area cannot preclude all problems or identify all potential solutions, but it will enable us to better achieve our end objective.

EXTERNAL INFLUENCING FACTORS

There are many factors that affect the efficient conduct of a weapon system acquisition program which are outside the influence of the individual project manager, and may lie outside the realm of the Department of Defense. Factors beyond the authority of the project manager that can only be solved by higher authority include other agencies' regulatory requirements, contractor lobbies to the Congress to redirect a program, and socio-economic requirements imposed by other agencies. Here again, our "can do" spirit takes over and we are reluctant to seek the necessary assistance from higher authority.

This is not to say that we should not attempt to solve our own problems, but rather that we should fully recognize the limits imposed on the authority we have to conduct the program. In many instances, the timely identification of these factors, and the subsequent notification of appropriate higher authority, will enable corrective action to be taken to eliminate the problem or reduce the impact. When this is not done, our efforts are frequently spent correcting the program rather than the problem.

Help or Hindrance?

A properly structured program review that receives the support of the program under review as well as the review authority can serve as an advocate to the program under review. Conversely, a poorly structured review without the support of both parties will probably serve to foster an adversary relationship and

thereby prove to be a hindrance to the acquisition process. To provide the "help" a program needs, the review authority requires only that the issues, both positive and negative, be presented in as clear and concise a manner as possible. From this straightforward approach will come help in the form of high-level management support that evolves from an understanding of the program and the peculiar aspects which identify it as a unique entity.

The "hindrance" to the acquisition process arises from absence of necessary information and the misinterpretation of poorly presented information. It is by no means an easy task, for either party. The program under review must endeavor to provide all pertinent details in an understandable context, and clearly state all issues for which management's attention is needed. The review authority, on the other hand, must resist the temptation to become "part of the problem" rather than "part of the solution." The review authority must ensure that the action requested is rendered as "help." If this is not possible, it must be acknowledged early.

An often-quoted axiom frequently applied to the review process states: "The more time I spend telling people about what it is I do, the less time I have to do that which I am supposed to do. Stability will be reached when I spend all of my time telling everyone about the nothing that I am doing."

It is essential that both reviewee and reviewer strive to provide the best reviews possible. Without this effort, the foregoing axiom will certainly persist.‖

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